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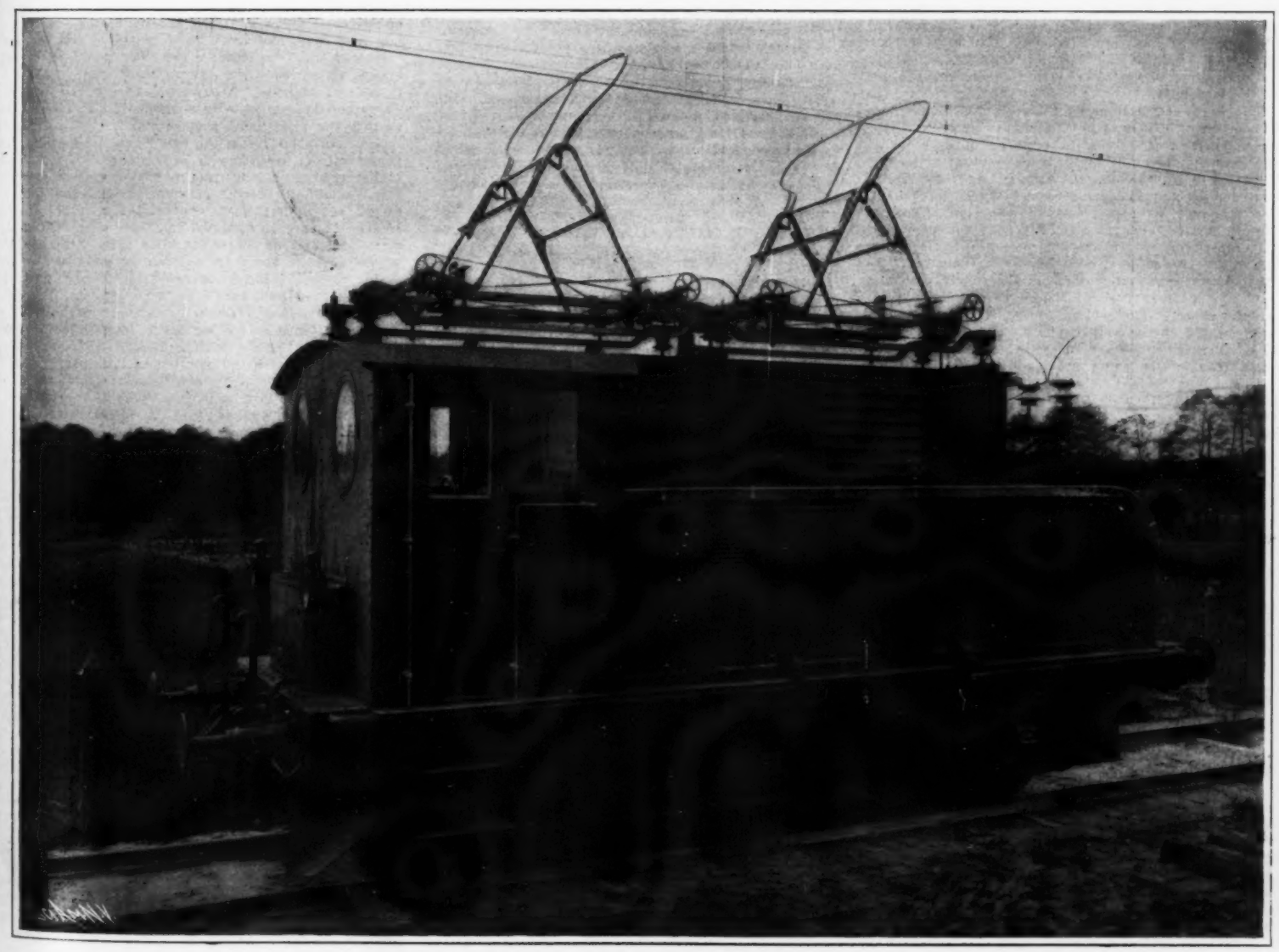
SINGLE-PHASE LOCOMOTIVE HAULING A TRAIN ON THE ROYAL SWEDISH RAILWAY.



A 20,000-VOLT SINGLE-PHASE LOCOMOTIVE.

SINGLE-PHASE LOCOMOTIVES AND MOTOR CARS IN BAVARIA AND SWEDEN.

SINGLE-PHASE LOCOMOTIVES AND MOTOR CARS IN BAVARIA AND SWEDEN.*

By FRANK C. PERKINS.

ONE of the most important electric railways using the single-phase system in Europe is that in the Bavarian highlands connecting the village of Oberammergau, which is well known throughout the world on account of the Passion Play, with Murnau, a station on the Bavarian State Railway.

Another important single-phase line is that in Sweden operated near Stockholm, where experiments have been made with electric locomotives using a pressure as high as 20,000 volts.

The locomotives of both these lines were furnished by the Allgemeine Electricitats Gesellschaft, and the Siemens-Schukert Werke of Berlin, in connection with the British Westinghouse Company.

The accompanying illustrations show one of these locomotives, as well as the track construction and overhead wires. One of the photographs shows the 20,000-volt single-phase locomotive, fitted with two bow-shaped collecting devices, and hauling a train on the Königlich Schwedische Staats Eisenbahn. This locomotive is provided with three motors, each having a capacity of 120 horse-power. Its total weight is 36 tons, and it was constructed for a speed of 45 kilometers (27.94 miles) per hour on the level when hauling freight trains, and 24 kilometers (14.9 miles) per hour on a grade of 10 per cent. For passenger service these locomotives are designed to operate at a speed of 65 kilometers (40.36 miles) per hour.

The locomotives have three driving axles 1,100 millimeters in diameter, with a wheel base of 1.7 and 2.3 meters.

These three axles are fitted with motors having a normal output, with a frequency of 25 periods and a pressure of 320 volts, of 110 horse-power; and the three motors have a drawbar pull of 6,000 kilogrammes, or 13,227 pounds. The wheels are fitted with air brakes made by the Vacuum Brake Company, of London. They are operated by two brake cylinders supplied with air from an electrically-driven pump of 7 horse-power capacity. Each locomotive is fitted with a transformer having a capacity of 300 kilowatts, this being of the air-cooled type so designed that the primary voltage employed may be 5,000, 10,000, 15,000, or 20,000 as desired.

Small 1.8 horse-power motors provide, for cooling purposes, an air blast of 40 cubic meters (1,712 cubic feet) of air under a water pressure of 75 millimeters (3 inches).

The secondary windings of the step-down transformers are so arranged that the motor pressure may be varied from 160 volts to 320 volts, in eight steps of 20 volts each; and connections are also provided for supplying a voltage of 120 to 240 volts, for supplying the necessary current for electric lighting and heating of the locomotive.

The Murnau-Oberammergau line is 23.6 kilometers (14.65 miles) in length and is supplied with a single-phase current directly at a pressure of 5,500 volts, the frequency being 17 cycles per second.

This single-phase electric railway was electrically equipped by the Siemens-Schukert Werke, of Berlin, and was only recently placed in operation. Ten-pole motors are used, designed for 270 volts and operating at a speed of 540 revolutions per minute normally. There are two motors, each having a capacity of 80 horse-power, mounted on each of the four cars which haul the various trains. These cars weigh 70,000 pounds apiece. The motors are of the conductively-compensated, series, single-phase, alternating-current type, subjected to voltage control, the secondary of the main transformer being provided with ten taps for this purpose, which make it possible to reduce the pressure from 270 volts when running to 17.5 volts at the start. The transformers, as well as the controllers, are located underneath the motor cars, the former being operated by a shaft connected by gearing with a large wheel. The controller is provided with a solenoid cut, and whenever it is necessary to interrupt the current the circuit breaker is utilized, in order that there shall be little or no burning in the controller after long service, and in order that the commutators may operate successfully through long periods of time.

The span wires are mounted on porcelain insulators held by wrought-iron side brackets attached to the poles, while porcelain strain insulators are inserted in the span wire, in order to make the insulation as perfect as possible. The insulation was given a most thorough test, with a pressure of 32,000 volts, under severe conditions of moisture similar to what is experienced in rainy weather.

For a distance of a little over one kilometer of track which is comparatively straight, a catenary line construction is employed, a steel messenger wire being supported above the middle of the track from porcelain insulators which are mounted on side brackets made of wrought iron. This steel wire supports two trolley wires, which are arranged over the rails in the same horizontal plane but in a zigzag course. The reason these wires are not placed perfectly straight instead of crossing back and forth in a zigzag manner will be clear when it is noted that bow collectors are very largely used in European railway service, and by this means of stringing the trolley wire the rubbing contact may shift from side to center on each hasp of the bow collector, and the resultant pressure will still be practically always at the center. For high speed and heavy service this construction is said to be most satisfactory. In the event of a trolley wire becoming broken at any of the railroad crossings, stations, or in the yards, the line is immediately grounded, somewhat in the same manner as on the Berlin-Zossen high-speed railway.

At the power house there is a net fall of 23.75 meters (76.92 feet), the canal supplying the water to the power house being 1,400 meters (4,593 feet) long and providing about 2 cubic meters (70.6 cubic feet) of water per second.

In the power house there are two 500-horse-power spiral turbines driving the high-voltage single-phase generator, and two 30-horse-power spiral turbines operating the exciter. These turbines were constructed at Heidenheim, and are of the Voith type. The large turbines operate at a speed of 240 revolutions per minute, and are each direct-connected to two electrical generators. One of these generators is a single-phase eight-pole, railway-type alternator, having a capacity of 280 kilowatts and supplying the current directly at 5,500 volts pressure. The other is a lighting generator with twenty poles and having a capacity of 150 kilowatts at a pressure of 5,000 volts.

The two small 30-horse-power turbines operate at a speed of 500 revolutions per minute, and each is direct connected to a continuous-current dynamo of 20 kilowatts capacity supplying direct current at a pressure of 150 volts. At Murnau there is a 60-kilowatt motor generator arranged to supply direct current at from 250 to 350 volts to a storage battery of 580 ampere-hours capacity. There is located at this sub-station a 60-horse-power auxiliary generating unit, and current is supplied for lighting on a three-wire system, which supplies 1,664 incandescent lamps of 16 candle-power each, 8 10-ampere arc lamps, and 13 motors.

At the Kohlgrub there are also two motor generators provided, the motor being of 45 horse-power and the dynamo of 30 kilowatts for supplying current to a storage battery installation having a capacity of 216 ampere hours. This equipment is also connected with a three-wire system of distribution containing 900 incandescent lamps of 16 candle-power in service, as well as a motor of 10 horse-power.

At Oberammergau there is also a sub-station equipped with a motor generator set consisting of a high-tension alternating-current motor of 85 horse-power direct-connected to a 55-kilowatt direct-current machine supplying a continuous current at 250 volts pressure for charging a storage battery of 430 ampere hours capacity.

The railway conductors consist of two circuits connected in series, the wires each being 35 square millimeters (0.542 square inch) in cross section.

The cars have second and third-class compartments, the former having a seating capacity for eight passengers, and the latter for twenty passengers, together with standing room for as many more. These are the winter cars, which weigh about 26 tons each, while the summer cars weigh 27.5 tons and have a seating capacity for sixteen passengers in the second class and thirty passengers in the third class. The cars operate at a speed of from 16 to 17 kilometers (9½ to 10½ miles) per hour, the trains being from 50 to 100 tons.

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE USES OF NATURAL ASPHALT IN THE ARTS.

By FELIX LINDENBERG.

THE varieties of asphalt that occur in nature have long been employed in various industries. At first they were used principally in the manufacture of artists' colors, next in the preparation of varnishes. No other important application of asphalt was made until the opening of the great Trinidad lake and other rich deposits.

One of these applications, which began about the middle of the nineteenth century, was to paving. It must be admitted, however, that early experiments in this field were not very successful. The asphalt pavements were not durable. On hot days in summer they often became so soft that they retained the impression of the heels of shoes, while in winter they became very brittle, cracked, and frequently separated in large sheets from their foundations, which commonly consisted of bricks laid loosely, without cement. These pavements, even when they were used only by pedestrians, went to pieces in a few years. Asphalt pavements did not attain their present value and importance until experience had shown that specially prepared bituminous or asphalt-bearing rock is the only material suitable for their manufacture.

The rapid development of the India-rubber and gutta-percha industry in the latter half of the nineteenth century gave rise to a new application of pure natural asphalt.

For some purposes it was found admissible and advantageous to mix caoutchouc with a large proportion of asphalt and great quantities of both natural and artificial asphalt are now used in this way.

The exceedingly small electrical conductivity of asphalt has also brought it into very extensive use as an insulator in the present age of electricity.

A recent and very interesting practical application of asphalt is to photography. In the infancy of the art it was discovered that the solubility of natural asphalt in its usual solvents is destroyed by exposure to light. The photographic process founded on this property is continually being improved and is coming into extensive use.

It appears from this brief review that the once neglected "mineral pitch" is now used in large quantities in various arts and industries, and it is to be expected that the number of its applications will increase with the advance of technology.

Some of the more important uses of natural asphalt will now be described more fully.

ASPHALT LACQUERS AND VARNISHES.

Pure natural asphalt is soluble in many liquids and the evaporation of the solvent, if volatile, leaves it in the form of a cohering layer and in possession of all its original properties. As pure asphalt is distinguished by its fine black color, which in dilute solutions passes into a warm brown, asphalt lacquers and varnishes are very extensively used—the more so because they adhere firmly to almost every known substance and may, therefore, be applied to every variety of wood, metal, and stone.

They may be divided into quick-drying oil, and mixed varnishes.

Quick-drying asphalt varnishes, in which only volatile solvents are employed, become quite dry in a few minutes after application. Oil asphalt varnishes, which are solutions of asphalt in linseed oil or linseed oil varnish, dry more slowly, as time is required for the oil to absorb oxygen from the atmosphere and thus become converted into a tough elastic coating. Mixed asphalt varnishes contain hard resins, such as amber or copal, dissolved in linseed oil varnish, in addition to the asphalt solution. They dry more rapidly than the preceding and are distinguished by great durability and resistance to external influences.

Quick-drying Asphalt Varnishes.—Natural asphalt is not entirely soluble in any liquid. Alcohol dissolves only a small percentage of it, ether a much larger proportion. The best solvents are benzol, benzine, rectified petroleum, the essential oils, and chloroform, which leave only a small residue undissolved. The employment of ether as a solvent is impracticable because of its low boiling point (36 deg. C. or 97 deg. F.) and great volatility. The varnish would dry almost under the brush. Chloroform is not open to this objection, but it is too expensive for ordinary use. Rectified petroleum is a good solvent of asphalt, but it is not a desirable ingredient of varnish because, though the greater part of it soon evaporates, a small quantity of less volatile substances, which is usually present in even the most thoroughly rectified petroleum, causes the varnish to remain "tacky" for a considerable time and to retain a disagreeable odor much longer. Common coal tar benzine is also a good solvent and has the merit of cheapness, but its great volatility makes the varnish dry too quickly for convenient use, especially in summer. The best solvent, probably, is oil of turpentine, which dissolves asphalt almost completely, producing a varnish which dries quickly and forms a perfect coating if the turpentine has been well rectified. The turpentine should be a "water white," or entirely colorless liquid of strong optical refractive power and agreeable odor, without a trace of smokiness. A layer one-fifth of an inch in depth should evaporate in a short time so completely as to leave no stain on a glass dish.

But even solutions of the best Syrian asphalt in the purest oil of turpentine, if they are allowed to stand undisturbed for a long time in large vessels, deposit a thick, semi-fluid precipitate which a large addition of oil of turpentine fails to convert into a uniform thin liquid. It may be assumed that this deposit consists of an insoluble or nearly insoluble part of the asphalt which, perhaps, has been deprived of solubility by the action of light. Hence, in order to obtain a uniform solution, this thick part must be removed. This can be done, though imperfectly, by carefully decanting the solution after it has stood for a long time in large vessels. This tedious and troublesome process may be avoided by filtering the solution as it is made, by the following simple and quite satisfactory method. The solution is made in a large cask, lying on its side, with a round hole about eight inches in diameter in its upper bilge. This opening is provided with a well-fitting cover to the bottom of which a hook is attached. The asphalt is placed in a bag of closely-woven canvas, which is inclosed in a second bag of the same material. The diameter of the double bag, when filled, should be such as to allow it to pass easily through the opening in the cask, and its length such that, when it is hung on the hook, its lower end is about eight inches above the bottom of the cask. The cask is then filled with rectified oil of turpentine, closed, and left undisturbed for several days. The oil of turpentine penetrates into the bag and dissolves the asphalt, and the solution, which is heavier than pure oil of turpentine, exudes through the canvas and sinks to the bottom of the cask. Those parts of the asphalt which are quite insoluble, or merely swell in the oil of turpentine, cannot pass through the canvas, and are removed with the bag, leaving a perfect solution. When all soluble portions have been dissolved, the bag, with the cover, is raised and hung over the opening to drain. If pulverized asphalt has been used the bag is found to contain only a small quantity of semi-fluid residue. This, thinned with oil of turpentine and applied with a stiff brush and considerable force, forms a thick, weather-resisting, and very durable coating for planks, etc.

The proportion of asphalt to oil of turpentine is so chosen as to produce, in the cask, a pretty thick varnish, which may be thinned to any desired degree by adding more turpentine. For use, it should be just thick enough to cover bright tin and entirely conceal the metal with a single coat. When dry, this coat is very thin, but it adheres very firmly and continually increases in hardness, probably because of the effect of light. This supposition is supported by the difficulty of removing an old coat of asphalt varnish, which will

not dissolve in turpentine even after long immersion and usually must be removed by mechanical means.

For a perfect quick-drying asphalt varnish the purest asphalt must be used, such as Syrian or the best Trinidad. Trinidad seconds, though better than some other asphalts, yield an inferior varnish, owing to the presence of impurities.

Of artificial asphalt, the best for this purpose is the sort known as "mineral caoutchouc," which is especially suitable for the manufacture of elastic dressings for leather and other flexible substances. For wood and metal it is less desirable, as it never becomes as hard as natural asphalt.

Oil Varnishes and Mixed Varnishes.—These contain linseed oil or linseed oil varnish and the mixed varnishes contain hard resins in addition. They combine the good qualities of asphalt with those of resin or linseed oil varnish and in durability and resistance to atmospheric influences they form the best varnishes known.

The simplest method of making oil asphalt varnish consists in diluting a very concentrated solution of asphalt in oil of turpentine, prepared as described above, with linseed oil varnish to a proper consistence for use. The oil of turpentine soon evaporates from the varnished object leaving a viscous layer of asphalt dissolved in linseed oil varnish, which gradually hardens, beginning at the surface, into a glossy, tough, and elastic coating, little affected by weather.

In the older methods the solution of the asphalt was effected by heat, simultaneously with the formation of the linseed oil varnish. One process is as follows: 120 pounds of linseed oil are heated to a high temperature in a kettle and 30 pounds of pulverized asphalt are then added gradually, with constant stirring. After all of the asphalt is dissolved, the kettle is heated more strongly and 6 pounds of litharge are added. The boiling is continued until the mass becomes so stiff that a cooled sample can be formed into a little ball. Then the fire is drawn and, when the mass has cooled to about 212 deg. F., 280 pounds of rectified oil of turpentine are added. After the contents of the kettle have been thoroughly mixed together by prolonged stirring they are left undisturbed long enough to allow any undissolved portions to settle. The clear varnish is then poured off and strained through cloths.

This process is not to be recommended, as the same result can be obtained by the simpler method of mixing the ready-made linseed oil varnish with a strong solution of asphalt in oil of turpentine. No heating is required, only thorough and prolonged stirring to mix the two liquids uniformly.

Many varnish makers add resin or black pitch in order to secure the desired consistency with a smaller proportion of asphalt, but the resulting varnish is of inferior quality, as neither pitch nor resin possesses the weather-resisting properties of asphalt, which constitute its especial merit.

A few often-reprinted formulas are given below, chiefly as illustrations of the circuitous methods often adopted to obtain a result which may be reached by far simpler means.

Dumas's Formula.—Melted amber, sandarac, mastic, resin, lac (?), each 15 parts; asphalt, black pitch, each 20 parts; turpentine 60 parts. Melt all these together, mix with 500 parts of boiled linseed oil, boil five minutes and filter.

Thenius's Formula A.—Coal-tar asphalt, American asphalt, resin, benzine, each 20 parts; linseed oil varnish, oil of turpentine, coal-tar oil, each 10 parts; binoxide of manganese, roasted lampblack, each 2 parts. The solid ingredients are melted together and mixed with the linseed oil varnish, into which the lampblack has been stirred, and, finally, the other liquids are added. The varnish is strained through tow.

Thenius's Formula B, for Carriage Varnish.—West Indian copal, American resin, natural asphalt, coal-tar pitch, each 10 parts; yellow wax, Venetian turpentine, each 2 parts. These ingredients are melted together and added gradually, with stirring, to a mixture of the following: Linseed oil varnish, oil turpentine, benzol, each 10 parts; heavy tar oil, 2 parts. If the varnish is too thick it may be thinned with from 5 to 10 parts of benzine.

It will be seen from the proportions of the various ingredients of these varnishes that asphalt plays so subordinate a rôle in them that they are not asphalt varnishes in the proper sense of the term. They are merely arbitrary mixtures and greatly inferior, in durability and other good qualities, to varnish composed chiefly of natural asphalt.

Mixed Varnishes Containing Hard Resins.—Of all applications used to adorn and protect the surface of objects oil varnishes or lacquers containing hard resins are the best as they furnish a hard, glossy coating which does not crack and is very durable even when exposed to wind and rain.

To obtain a varnish of these desirable qualities the best old linseed oil, or varnish made from it, must be combined with the residue left by the dry distillation of amber or very hard copal. This distillation removes a quantity of volatile oil amounting to one-fourth or one-fifth of the original weight. The residue is pulverized and dissolved in hot linseed oil varnish, forming a thick, viscous, yellow-brown liquid, which, as a rule, must be thinned with oil of turpentine before being applied.

Hard resin oil varnish of this sort may conveniently be mixed with the solution of asphalt in the oil of turpentine with the aid of the simple apparatus described below, as the stiffness of the two liquids makes hand stirring slow and laborious. A cask is mounted on an axle which projects through both heads, but is inclined to the axis of the cask so that when the ends of the axle are set in bearings and the cask is revolved, each end of the cask will rise and fall alternately, and any liquid which only partly fills the cask will be thoroughly mixed and churned in a short time. The cask is two-thirds filled with the two thick varnishes (hard resin in linseed oil and asphalt in the oil of turpentine) in the desired proportion, and after these have been intimately mixed by turning the cask, a sufficient quantity of rectified oil of turpentine to give proper consistence is added and the rotation is continued until the mixture is perfectly uniform.

To obtain the best and most durable result with this mixed oil, resin, and asphalt varnish it is advisable to dilute it freely with oil of turpentine and apply two or three coats, allowing each coat to dry before the next is put on. In this way a deep black and very glossy surface is obtained which cannot be distinguished from genuine Japanese lacquer.

Many formulas for making these mixed asphalt varnishes contain resin—usually American resin. The result is the production of a cheaper but inferior varnish. The addition of such soft resins as elemi and copaiba, however, is made for another reason, and it improves the quality of the varnish for certain purposes. For though these resins soften the lacquer they also make it more elastic, and therefore more suitable for coating leather and textile fabrics, as it does not crack in consequence of repeated bending, rolling and folding.

Elastic Asphalt Varnish.—A solution of 1 part of caoutchouc in 16 parts of oil of turpentine or kerosene is mixed with a solution of 16 parts of copal in 8 parts of linseed oil varnish. To the mixture is added a solution of 2 parts of asphalt in 3 or 4 parts of linseed oil varnish diluted with 8 or 10 parts of oil of turpentine, and the whole is filtered.

Thenius's Elastic Asphalt Varnish.—American asphalt, coal-tar asphalt, American resin, each 5 parts; yellow wax, paraffine, each 1 part. These are melted together and heated for two hours with 20 parts of linseed oil varnish, after which 1 part of very finely pulverized Prussian blue is added. The temperature is then raised until the mass begins to give off brown fumes and a cooled sample can be drawn into long threads. Five parts each of rectified oil of turpentine, benzol, and chloroform are then added. This varnish gives a glossy, blue-black lacquer which dries very rapidly. In this very arbitrary formula both the benzol and the chloroform might very well be replaced by additional quantities of the much cheaper rectified oil of turpentine.

Asphalt Engravers' Varnishes, or "Etching Grounds."—In copper-plate engraving the plate must be covered with a dark-colored coating which, though entirely unaffected by the etching fluid, must be soft enough to allow the finest lines to be drawn with the needle and must also be susceptible of complete and easy removal when the etching is finished. Varnishes which possess these properties are called "etching grounds." They are made according to various formulas, but in all cases the principal ingredient is asphalt, of which only the best natural varieties are suitable for this purpose. Another common ingredient is beeswax, or tallow.

Etching grounds are usually made in small quantities, at a single operation, by melting and stirring the solid ingredients together and allowing the mass to cool in thin sheets, which are then dissolved in oil of turpentine. The plate is coated uniformly with this varnish through which the engraver's tool readily penetrates, laying bare the metal beneath. After the lines thus drawn have been etched by immersing the plate in acid, the varnish is washed off with oil of turpentine.

Four formulas for etching grounds are given in the following table:

	I.	II.	III.	IV.	
Yellow wax.....	50	30	110	40	parts.
Syrian asphalt...	20	20	25	40	parts.
Resin	..	..	..	20	parts.
Amber	..	..	20	..	parts.
Mastic	25	25	25	..	parts.
Tallow	..	..	..	2	parts.
Burgundy pitch..	..	..	..	10	parts.

THE USE OF ASPHALT IN PAINTING.

A solution of asphalt leaves, on drying, a fine black or brown stain, according to the strength of the solution, and consequently asphalt is included in the list of artists' colors, though many artists object to its use for reasons which cannot be discussed here. The pigment called asphalt or bitumen is usually made by mixing amber or hard copal varnish with a solution of asphalt in oil of turpentine and thinning the mixture to the desired consistence with boiled linseed oil. A fine and quickly drying asphalt brown may be made by extracting very finely pulverized Syrian asphalt with alcohol, mixing the insoluble residue, when dry, with one-third of its weight of amber colophony (the residue left in the distillation of amber) and heating the mixture with linseed oil until a homogeneous mass is produced.

Experiment has shown that the portion of Syrian asphalt which dissolves in benzine is of especial value for artists' use. This extract, when mixed with linseed oil and gently heated until all the benzine has evaporated, forms a pigment which possesses, in comparison with other asphalt colors, the advantage of drying both quickly and completely, instead of remaining "tacky."

THE USE OF ASPHALT IN PHOTOGRAPHY AND PHOTO-ENGRAVING.

The art of photo-engraving has now reached so high a stage of development that the printing press produces copies of photographs that can scarcely be distinguished from the originals. The earliest photo-engraving process was based on the property possessed by asphalt of becoming insoluble on exposure to light. Niépce experimented with solutions of asphalt as early as 1814 and his results were, consequently, not only the first photo-engravings but the first photographic pictures of any sort ever made.

Niépce coated sheets of metal thinly with a solution of asphalt in oil of lavender and, after they had dried, exposed them to sunlight under engravings, laid face down on the varnished metal. The sun's rays penetrated the unprinted parts of the paper and made the asphalt beneath them insoluble, but it was stopped by the lines of the engraving, under which, therefore, the asphalt remained soluble. After sufficient exposure to light the metal plate was washed with an ethereal oil, which dissolved the still soluble parts of the coating without affecting the other parts. The result was a series of lines and points of exposed metal corresponding to the lines and points of the original engraving and separated by asphalted areas. The plate could therefore be etched and printed exactly as if the lines had been drawn with the needle, as described above.

In comparatively recent times it was discovered that gelatine sensitized with alkaline bichromates is also made insoluble by light, and various methods of printing from plates which had been covered with bichromated gelatine and exposed to light under photographic negatives and diapositives were invented. At present both asphalt and bichromated gelatine are used in photo-engraving, the resumption of the employment of asphalt being largely due to Valenta's investigation of the sensitiveness of solutions of asphalt to light.

It has long been known that the constituents of which asphalt is composed differ greatly in solubility and also in the effect of light upon solubility. From Kayser's investigations it appears that asphalt is essentially a mixture of three similar resinous compounds whose greatest difference is shown in the proportions of sulphur which they contain. These resins are distinguished by the letters α (alpha), β (beta), and γ (gamma).

The alpha resin has the chemical formula $C_{72}H_{96}S$ and contains about 7 per cent of sulphur. It is soluble in alcohol and entirely unaffected by light.

The beta resin has the formula $C_{72}H_{96}S_2$ and contains 10 per cent of sulphur. It is soluble in ether and is sensitive to light.

The gamma resin has the formula $C_{72}H_{96}S_3$ and contains 13 per cent of sulphur. It is soluble in chloroform and is more sensitive to light than the beta resin.

Valenta began his investigation with the conjecture that the sensitiveness of asphalt to light would be increased if its less highly sulphureted components could be converted into the gamma resin, which contains the largest percentage of sulphur, and the results of his experiments proved the correctness of the supposition.

He began by heating Syrian asphalt with flowers of sulphur and the higher hydrocarbons of the benzol series, using first toluol, then xylol and finally crude cumol, which boils at 170 deg. C. (338 deg. F.). His selection of hydrocarbons was necessarily restricted to such as do not readily combine with sulphur.

One hundred parts of Syrian asphalt and a solution of 12 parts of sulphur in 100 parts of cumol were heated together in a retort provided with a condenser arranged in such a manner that the condensed vapor of the boiling cumol flowed back into the vessel. During the operation, which was continued for three or four hours, large quantities of sulphureted hydrogen were given off. When the evolution of gas had nearly ceased the cumol was distilled off, leaving in the retort a mass resembling pitch.

A solution of 4 parts of this modified asphalt in 100 parts of benzol, when spread on a metal plate and allowed to dry, proved to be far more sensitive to light than even the gamma resin which remains after the alpha and beta resins of natural asphalt have been successively extracted by alcohol and ether.

On analysis the sulphureted asphalt was found to contain no alpha resin and but little beta resin, these constituents having evidently been converted into gamma resin or even into a compound with a still higher percentage of sulphur, as the great sensitiveness of Valenta's prepared asphalt would suggest. It is not necessary, however, to coat the plates in a dark room or by red light and the sensitiveness is increased by exposing the solution to diffused daylight for half an hour before use. The solution should be sufficiently dilute to give a golden yellow coating on zinc. After exposure the soluble parts are washed off into benzol or some other solvent.

THE USE OF ASPHALT IN THE INDIA-RUBBER INDUSTRY.

Asphalt is so similar to caoutchouc in many of its properties that it was early used as an addition to that substance. The growing demand for and scarcity of caoutchouc have led to an immense development of this use of asphalt, especially artificial asphalt or coal tar pitch which, because of its cheapness, is commonly used for this purpose. Crude rubber in fine shavings is mixed with pulverized asphalt and other substances and kneaded into a homogeneous mass by passing repeatedly between hot rollers. The composition known as "plastite" contains, for each 100 parts of caoutchouc, 50 to 60 parts of coal tar asphalt, 60 to 75 of sulphur,

and 40 to 50 of magnesia—the last being added merely as a "filler" to increase the bulk of the product. The mass, when softened by heat, can be forced with powerful presses into iron molds of any desired form, in which it is "burnt" or vulcanized, that is, heated until the sulphur and caoutchouc combine. The hardness of the objects depends on the vulcanizing temperature, a comparatively low temperature producing a mass as soft and elastic as ordinary vulcanized rubber and a high temperature giving a product similar to "hard rubber" or ebonite. A special variety of plastite, called artificial whalebone or balenite, is an excellent substitute for genuine whalebone.

Old articles of vulcanized rubber are first "devulcanized" by grinding, boiling with caustic soda, and washing thoroughly. After drying, the scraps are heated to 150 deg. C. (302 deg. F.) with linseed oil in a kettle provided with stirring mechanism which is kept in continual motion. When the rubber has dissolved a quantity of natural or coal tar asphalt is added and, as soon as the contents of the kettle have become well mixed, the temperature is raised so high that dense fumes begin to rise and air is forced through the mass until a cooled sample shows the desired consistence. This composition, being very tough and flexible, forms an excellent covering for electric cables. It finds many other uses, the proportions of rubber, asphalt, and oil being varied in accordance with the purpose for which it is designed.

An insulating material which contains no caoutchouc is made by dissolving natural or coal tar asphalt in wood oil, adding sulphur and vulcanizing at 300 deg. C. (572 deg. F.). The mixture of asphalt and wood oil may also be vulcanized with chloride of sulphur by the ordinary process used for caoutchouc. Before vulcanizing, a solution of rubber scraps in naphthaline is sometimes added and the naphthaline expelled by a current of steam. Substitutes for hard rubber are made of natural or artificial asphalt combined with heavy oil of tar and talc or infusorial earth.

Waterproof cloth is prepared with a mixture of caoutchouc, asphalt, petroleum, and its heavy oils and a small quantity of vaseline. The cloth is run through the composition and then between rollers which remove the excess.

A cement used in fastening electric bulbs to their metal sockets is made by melting together equal parts of natural asphalt and resin and stirring into the molten mass sufficient clay to enable it to be readily put into the sockets with a spoon. Another insulating composition, useful as a cement and for other purposes, is made by expelling the most volatile part of natural asphalt (about 10 per cent) by prolonged heating to 100 deg. C. (212 deg. F.), dissolving the residue to benzine and thickening with clay or infusorial earth.

Most of the insulating materials advertised under alluring names consist of asphalt combined with resin, tar, and an inert powder such as clay or asbestos. Some contain graphite, which is a good conductor and therefore a very undesirable ingredient in an insulator.

Tape for winding wire splices may be impregnated with a mixture of asphalt and tar. This composition is a good insulator but it crumbles after long exposure to the air.

Marine Glue.—This important substance possesses the valuable property of protecting metal from the corrosive action of sea water.

In the ordinary process of making marine glue finely-shredded caoutchouc is heated, with continual stirring and kneading, with about 12 times its weight of petroleum and the thick, homogeneous liquid thus produced is stirred and heated with 6 times its weight of natural or coal tar asphalt. The mass solidifies in cooling. When wanted for use it is melted—cautiously, to avoid burning on the bottom of the vessel—and heated to so high a temperature that it becomes thin enough to be applied without any admixture. Wire brushes are used, as bristle brushes would be destroyed by the hot glue. The jet black coating adheres very firmly and gives perfect protection against air, moisture and sea water.

A still more durable lacquer may be given to metal objects that can be heated to a high temperature by adding a small proportion of sulphur to the glue in the process of manufacture and heating the objects, after the coating has been applied, to from 250 to 270 deg. C. (about 500 deg. F.) to vulcanize the rubber. The result is a lacquer like hard rubber, extremely resistant to all external influences and very durable.

This variety of marine glue is especially suitable for small metal objects which are subjected to much wear. "American lacquer," which is so highly and so justly prized for its good qualities, is nothing else, as a rule, than marine glue properly made and "burnt" after application.

Marine glue can also be used cold, by dissolving it in benzol (not benzine) or in rectified oil of turpentine. The latter solvent is cheaper than benzol but it produces a lacquer which is inferior in gloss and beauty.

POROUS CONTACT.—K. Prytz describes a novel device for making gas-connections in vacuum tubes. The vacuum tube is closed at one end with a porous plug made preferably of fire-clay. As long as the plug is kept immersed in mercury the gas cannot pass in or out through the plug, provided the pores in the plug are so small that mercury cannot be forced through them by a pressure of one atmosphere. The gas with which the vacuum tube is to be filled is contained in another tube provided with a similar plug. When the gas is to be transferred, the plugs are brought into contact under the mercury, and the pump is worked. Many difficulties are thus avoided, and the only drawback is the slow diffusion of the gas through the plugs. —K. Prytz, Annalen der Physik, No. 13, 1905.

NOTES ON HEAT INSULATION, PARTICULARLY WITH REGARD TO MATERIALS USED IN FURNACE CONSTRUCTION.*

By R. S. HUTTON and J. R. BEARD.

INTRODUCTION.

THE importance of a knowledge of the heat conductivity of the materials used for the bricks or linings of furnaces scarcely needs to be emphasized. There is no doubt that a careful study of this subject would enable a very large saving to be effected in the fuel or other heating costs in many experimental and industrial furnaces.

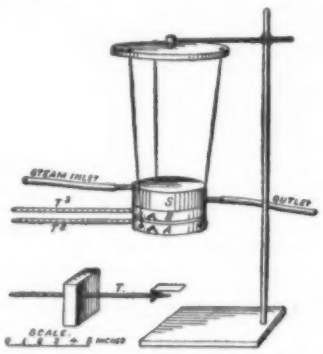


Fig. 1.—Apparatus of Lees and Chorlton for Measurement of Thermal Conductivity of Bad Conductors.

A = Round disk of brass on which the substance under investigation is placed; it is suspended from a horizontal support by three strings. The disk is 11.4 centimeters diameter and 1.3 centimeters thick. The powders are kept in position by a thin ring of red fiber, which in the present work was about 0.36 centimeter high.

B = Upper disk of brass of same dimensions as *A*. It is surmounted by the steam box *S*, which is covered with felt to diminish the loss of heat.

A and *B* are provided with projecting pegs, the distance apart of which gives a measure of the thickness of insulating material.

T is a thermometer registering the temperature of the air; it is provided with a screen to protect it from radiated heat from the lower disk.

T_2 and T_3 indicate the temperature of the lower and upper disk respectively; they are inserted into radial holes drilled in the brass.

The manufacturer and purchaser of refractory products both seem to ignore the necessity for accurately determining the quality of their material so far as its heat insulating power is concerned. Their specifications are confined to other properties, but it is doubtful if any of them are of greater economic importance than the heat conductivity.

So far as laboratory crucible and muffle furnaces are concerned H. H. Cunynghame† has recently shown how greatly the efficiency can be improved by the adoption of better insulation.

Despite this lack of knowledge the measurement of thermal conductivities of such materials is by no means difficult to carry out, at any rate to within an accuracy of 2 or 3 per cent. C. H. Lees and J. D. Chorlton‡ have specially designed a simple apparatus for measuring the thermal insulation of bad conductors. We are much indebted to Dr. Lees, who very kindly lent the apparatus and also gave much valuable advice in carrying out the experiments.

MEASUREMENT OF THERMAL CONDUCTIVITIES OF GRANULAR MATERIALS UP TO 100 DEG. C.

All the substances dealt with have been either in the state of well-defined granular powders, or in some few cases where bricks have been examined, these were previously broken up and finely powdered. The apparatus of Lees and Chorlton was originally designed for round tiles or plates of material, but these have to be of uniform thickness and 11.4 centimeters diameter, and the shaping of bricks is not easily accomplished in the laboratory. A sketch of the apparatus is given in Fig. 1. It consists essentially of two thick metal disks between which the material is placed whose thermal conductivity has to be measured. The upper disk is surmounted with a steam jacket, while the lower one is allowed to cool by free conduction and radiation. Three thermometers are used, one to give the temperature of the upper, the second that of the lower disk; while a third gives the temperature of the surrounding air. The thermometers are inserted into radial holes drilled in the disks and thus denote their temperature with fair accuracy. When steam is passed through the steam jacket the temperature of the upper disk is raised to nearly 100 deg. C., heat flows through the material experimented on and thus raises the temperature of the lower disk above that of the surrounding air. The lower disk loses heat by conduction and radiation to the air. Eventually a steady state is reached, when this loss of heat is equal to the heat received through the material experimented on.

The following equation enables the thermal conductivity (K) to be calculated from the result of such an experiment provided h_1, the external conductivity or "emissivity," has been previously determined.

$$K = \frac{t_2 - t_1}{t_3 - t_2} \cdot b \left(h_1 + h_1' + \frac{ph_1}{2q} \cdot b\right)$$

Where t_1, t_2, t_3 are the temperatures indicated by the thermometers T, T_2, and T_3 respectively, and b denotes the thickness of the layer of powder.

The value of h_1 is determined in a separate experiment from the rate of cooling of the lower disk at different temperatures.

In all the experiments here recorded the thickness was practically the same (0.360 centimeter), and as in nearly all cases the thermal conductivities were much of the same order, the term in the bracket was very nearly constant and equal to 0.00045.

Substance.*	Thickness in Cm.	Temperatures, Deg. Centigrade. t_3	t_2	t_1	Conductivity. K.
Sand, white Calais	0.360	98.4	81.0	18.2	0.0060
Carborundum (fine)	0.363	98.7	78.8	18.3	0.0060
Carborundum (coarse)	0.358	98.7	79.6	18.7	0.0061
Quartz, "enamel"	0.362	99.3	75.4	21.7	0.0036
Quartz (fused)	0.362	98.9	74.9	17.4	0.0039
Firebrick	0.363	98.7	69.2	20.3	0.0028
Retort graphite	0.363	100.0	76.6	19.6	0.0040
Lime	0.363	98.1	70.1	20.8	0.0029
Magnesia (fused)	0.356	98.7	78.6	20.0	0.0047
Magnesia, "Mabor" brick	0.360	99.7	80.0	18.8	0.0050
Magnesia, calcined Greek	0.365	99.3	78.3	20.4	0.0045
Magnesia, calcined "Veitsch"	0.366	99.7	73.9	20.0	0.0034
Magnesia, Pattinson's light calcined	0.363	98.0	58.5	19.7	0.0016
Kieselguhr (infusorial earth)	0.366	97.9	53.9	17.7	0.0013

* Most of these granular powders just passed through a sieve with 600 meshes per square centimeter.

RELATIVE VALUE OF DIFFERENT HEAT INSULATING MATERIALS AT HIGH TEMPERATURES.

It is not advisable to choose a material suitable for furnace uses from the above data alone.

First, it is always necessary to know the general effect upon the substance under investigation of such temperatures as are likely to be experienced. Several, even among those materials mentioned in the table, are unsuitable for subjecting to high temperature on account of the physical changes, such as shrinkage, which they undergo. Chemical action, especially oxidation, also renders many insulators unsuitable for a large number of purposes.

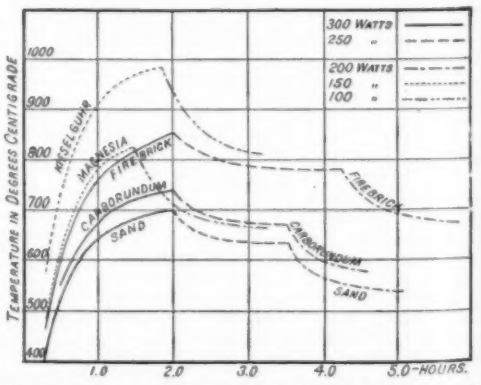


Fig. 3.—Curves Showing Relative Insulating Power of Materials.

Secondly, having by such considerations excluded all unsuitable materials from the choice, it becomes necessary to compare the relative efficiency of those which remain under conditions more nearly approaching those experienced in practice.

The following experiments were carried out with a view to testing in as simple a manner as possible the behavior of various refractory materials at comparatively high temperatures.

The method employed, although it does not directly lend itself to the accurate measurement of the absolute conductivities, at any rate offers a practical means for making comparative tests.

DESCRIPTION OF APPARATUS.

A modified form of electrically-heated tube furnace was employed. An unglazed porcelain tube, with a

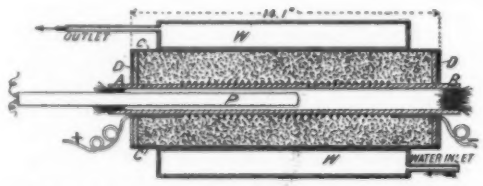


Fig. 2.—Apparatus Used for Comparison of Heat Insulators at High Temperatures.

A, *B*, Unglazed porcelain tube with heating coil of nickel wire wound on its central portion.

The porcelain tube is kept in position at the center of the cylinder of sheet iron *C*, *C*, by washers of asbestos card, *D*, *D*.

W, *W* is the water jacket surrounding the cylinder *C*.

P is a thermo-electric pyrometer by which the temperature is indicated.

The granular insulating material under test fills the space between the porcelain tube and sheet-iron cylinder.

* A paper read before the Faraday Society.

† Journal Society of Arts, vol. liii., p. 72, December 11, 1903; also Engineering, December 11, 1903.

‡ Phil. Mag., June, 1896 (5), vol. xli., pp. 495-503.

heating coil of nickel wire, is supported at the center of a cylindrical, water-cooled inclosure, the space between the heating coil and the inner wall of the inclosure being filled with the granular material under investigation. (See Fig. 2.) The electric energy expended in the wire is kept constant over a considerable period by careful adjustment of an external resistance and constant observation of a precision wattmeter. The temperature at the center of the porcelain tube is noted at regular intervals, and from the observations a curve is plotted to show the relation between the rise of temperature and the time during which the heating has been in progress. The temperature of the water flowing through the external jacket was kept fairly constant; generally it varied some 2 deg. C.

In such an experiment it would require a very long time for the temperature to attain a constant value. It was, therefore, found preferable, after the rate of increase in temperature had become rather slow, to reduce the power by a small but definite amount. Under these conditions the temperature falls, at first very rapidly, but soon reaches a constant value, or at any rate, falls so slowly as to be almost negligible. It is from a comparison of the heating curves with different materials and the same expenditure of power, and particularly from the nearly horizontal portion of the curves with lower power expenditure, that valuable conclusions can be drawn.

The accompanying diagram (Fig. 3) illustrates some of the results obtained.

In the case of firebrick, carborundum, and sand, the preliminary heating was effected with 300 watts, and after the lapse of about two hours the power was reduced to 250 watts, being kept constant at this for a period of one and a half to two hours, by which time the temperature had become almost constant. The curves for kieselguhr (infusorial earth)* and light magnesia clearly show the very much smaller conductivity of these materials.

With these two substances the preliminary heating was effected with an expenditure of only 150 watts, but despite this the rise in temperature is more rapid than with any of the other materials mentioned.

Unfortunately, neither light magnesia nor infusorial earth can withstand any high temperatures for long without losing their efficiency to a considerable extent. Both substances exhibit large shrinkage at high temperature, and their chief uses are likely to be limited to external jacketing of furnaces lined with some more permanent but less good insulator.

To more thoroughly test the above method of comparing the relative efficiency of different materials at high temperatures, it was thought advisable to see what influence the preliminary heating might have on the results.

Two similar experiments were therefore carried out with the various substances. In the first case the preliminary stage of the heating was effected with 300 watts, in the second with 250 watts. In both cases the power was subsequently reduced to 200 watts and then to 150. The results showed that in all those cases in which no permanent alteration is brought about in the materials under test, the horizontal portions of the curve are practically identical, whatever the preliminary treatment had been.

In earlier experiments, in which no water cooling had been used to maintain constant the temperature of the outer jacket of the inclosure, some anomalous results were obtained.

GENERAL CONCLUSIONS.

The above results will, it is hoped, prove of value to those who have to deal with refractory materials. The subject seems to have been much neglected, considering that the thermal conductivity of such substances is the characteristic property which is really applied in their many uses.

While bricks and generally jacketing materials for furnaces should be of low thermal conductivity, it is of no less importance to choose crucibles, retorts, and other containing vessels which are heated externally of as high conductivity as is feasible in conjunction with their other necessary qualities. Such methods as have been described are equally applicable to this latter case.

By a judicious use of the different materials and a *stratified* form of construction, it should be possible usefully to employ such excellent insulators as infusorial earth without risk of the damage which is inevitable if they be permanently subjected to too high a temperature.

The above experiments were carried out in the Physical Laboratories of the Manchester University.

It was not until the eighteenth century that brandy making became generally practised in Europe. The brandies from white wines are better in quality than those from red wines, and, in some of the leading brandy districts, particular white wine varieties are grown for brandy purposes, one of the favorite varieties being the Folle Blanche. One thousand gallons of wine yield from 100 to 180 gallons of proof brandy, depending, of course, on the sugar in the grapes or the alcoholic strength of the wine. Practically all the grape brandy made in the United States for commercial purposes comes from California, where brandy making has for some years been quite a large and profitable industry. Large quantities are used in the manufacture of sweet wines, and the annual average output of commercial brandy in the State is in the neighborhood of 750,000 gallons.

* Cf. F. A. J. FitzGerald, Electrochemical Industry, 1905, vol. iii., p. 55.

[Continued from SUPPLEMENT No. 1582, page 25346.]

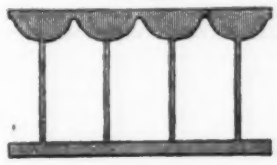
RESERVOIR, FOUNTAIN, AND STYLOGRAPHIC PENS.—IV.*

By JAMES P. MAGINNIS, A.M.Inst.C.E., M.Inst.Mech.E.

STYLOGRAPHIC PENS OF TO-DAY.

THE invention of the vibrating needle-pointed pen introduced a revolution in the mode of writing, far more perhaps, than did the invention of steel or gold nibs. The great novelty and innovation on the then customary mode of writing, and their necessarily high

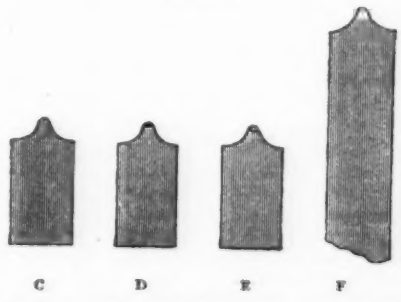
FIG. 102.



cost when first introduced, stood very much in the way of their immediate acceptance as writing implements. As compared with the fountain pen (with its nib) the advantages claimed are, that it is much cheaper, and that the film of ink it distributes on the paper is so thin that it dries almost immediately. It is not, strictly speaking, a pen at all, but it has been more truly described as a fluid pencil, and the sensation of writing with a stylographic pen is very similar to that experienced when using a pencil. When properly adjusted it glides along smoothly and noiselessly, but in use the characteristic of one's handwriting is naturally more or less lost.

I have hitherto referred to stylographic pens in

FIG. 103.

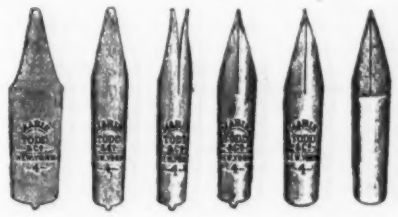


chronological order, that being the most convenient method for this lecture. There still remain a few which I have not yet described, which deserve a prominent place, on account of their excellence. These will be recognized in the following illustrations, which were made from a series of drawings I prepared some time ago to illustrate leading types of stylographic pens, and this fact accounts for a slight repetition of some of those already described.

* Journal of the Society of Arts.

The Wilson stylus, a complete section of which is shown in Fig. 93, has already been described, but a drawing of it happened to be included in this engraving. It was made in vulcanite, as well as in metal, and I have some examples of these pens in both materials given me by their inventor. Those in metal are either nickel plated or gilt, and are objectionable

FIG. 104.



on account of their weight, which is considerable for a pen. The inventor, however, Mr. N. Wilson, partner of the well-known firm of Wheeler & Wilson, deserves credit in that he set himself to produce a practical pen at a low price, and this he succeeded in doing, as his pens were sold in 1880 at half a crown each.

FIG. 93.

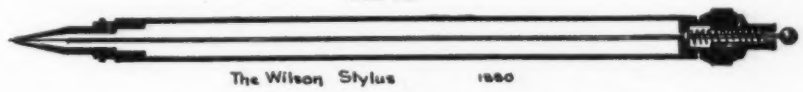


FIG. 94.

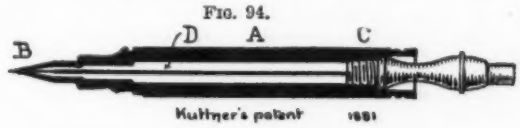


FIG. 95.

FIG. 96.

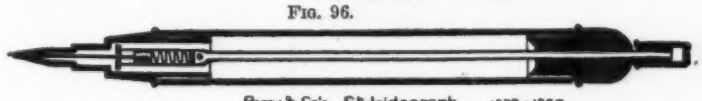


FIG. 97.

FIG. 98.

FIG. 99.

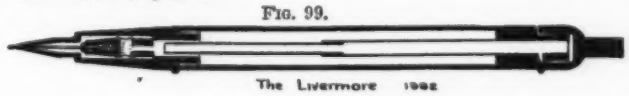
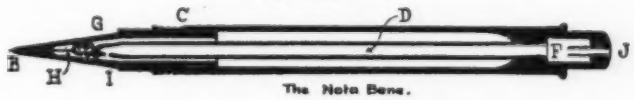


FIG. 100.

FIG. 101.



One could not rely on them as pocket pens, for they soon acquired an unpleasant habit of leaking. Furthermore, the points were too soft and soon wore out.

A provisional patent (3,205) for the pen shown in Fig. 94 was obtained by J. Kuttner in July, 1881. This pen consisted of two parts only, and the section here shown is taken from an actual example in my possession. The reservoir, *A*, terminates in the usual manner, in a tapering writing point, *B*. An adjustable screw plug, *C*, screws into the other end of *A*, and forms a valve which may be opened or closed by screwing the plug out or in. A wire, *D*, of metal, and of uniform diameter throughout, except at the extreme point, is fixed firmly in the plug, *C*, and is just long enough to reach the point passing through a minute parallel hole. In the act of writing, this wire vibrates to an extent controlled by the distance it protrudes through the writing point, this being regulated by the plug, *C*, which simultaneously regulates the air supply to the ink reservoir. This pen point was, like that of the Wilson stylus, too soft, and did not last long.

In Fig. 95 is another drawing of the Cross pen, which has already been fully described, and I have nothing to add except, perhaps, to give the pen a word of commendation, in that one of these served me well for many years, and was only cast aside as a result of an accident.

About 1879 or 1880, Messrs. Perry & Co. introduced a very handsome-looking stylo-pen, which they called the "Styloidograph," and which is shown in section in Fig. 96. It was very similar in construction to the

Cross pen, Fig. 95, having an air tube extending from the extreme upper end, and terminating in a spring box containing a piston or plunger to which the needle was attached. The barrel or reservoir was of richly-chased vulcanite, and the plug and cap, as well as the point section, were of gilt metal, presenting a smart appearance, which did not detract from its effective working.

Fig. 97 is a section of the point of a pen, advertised by Messrs. Burge, Warren & Ridgley as the "British stylographic pen," working on much the same principle as that of Cross. It will be noticed that the air tube is telescopic, thus forming a ready means of adjusting the position of the needle.

In Fig. 98 the writing point of the stylograph known as the "Independent" is shown in section. The needle in this case is fixed rigidly in the end of the air tube, relying on its own flexibility for freedom in writing.

Mr. C. W. Robinson has a metal pen, made in 1868 by himself, in which the rigid needle is used as here illustrated.

The "Livermore" has already been referred to. It is shown in section in Fig. 99, and it will be seen that the box carrying the spring, and the plunger to which the needle is attached, is a fixture in the point section into which it is screwed, and is not attached to the air tube as in previous examples. It was in its day a very excellent pen, but it is now seldom seen. One of these pens, which I carried regularly for some years away back in the early eighties, only failed as the result of falling on a railway platform some twenty years ago. This pen has now been repaired and is in perfect working order.

Fig. 100 shows a section of the "Riverside" pen. One of the advantages claimed for this pen lies in the method of holding the needle. A flat strip of silver is bent into the form shown below the pen, and passing through a hole in the fold is placed the needle, free to rise and fall with the spring. This combination is pushed into the point section, where it is held steadily by the effort of the silver strip, or yoke (as it is called), to expand, and the needle may readily be adjusted by raising or lowering the yoke as required. Although this ingenious little arrangement is here associated with the "Riverside" pen, I am under the impression that it is the invention of a Mr. Brown, whose name is well known as the inventor of a fountain pen which I shall refer to in my next lecture. The "Riverside" pen is one of the specialties of the London Pen Company, founded by Mr. C. W. Robinson.

De la Rue's Stylograph.—This consists of the usual number of parts, viz., the cap, the point section, and the barrel, as shown in section in Fig. 101. The cap is similar to the caps of fountain pens, but is provided with a small pad or cushion of India-rubber, the object of which is that of a safeguard to prevent any possible leakage of ink from the point when the cap is in position. The point section is formed as shown, terminating in a tapering point, which again terminates in a very small metal tube skillfully inserted therein. The barrel is a vulcanite cylinder or tube into one end of which the point section screws, as shown at *C*, while into the other end (which is practically solid) is fitted a vulcanite tube, *D*, of small diameter, extending the entire length of the barrel. The end of this tube is open to the outer atmosphere through the chamber, *F*, and the hole, *J*; its other end, *G*, is sealed, and terminates in a short solid spindle upon which is fixed a coiled wire, extending forward in a straight line as shown at *B*. This wire is of such diameter and length as to pass freely through the point, and just protrudes beyond *B*, when the point section is screwed home. One can readily recognize here the invention of Mr. Shaw of 1898, already described. Close to the sealed end *G*, of the air tube, there is a small hole, *I*, which establishes communication between the interior of the air tube *D* and the barrel.

The pen being filled the ink runs down into the very restricted annular space between the wire, *B*, and the point, *B*, and thence on to the paper. At the same time air is being admitted through the chamber, *F*, and the air tube, *D*, to the opening, *I*, whence it bubbles up through the body of ink. In the chamber, *F*, is fixed a short tube open to the outer air at *J*. This tube forms an effective trap, as previously described, preventing the ink from leaking through the air vent, *J*, should a drop happen to find its way there, in case the pen be held in an inverted position.

Altogether this is a very beautifully made instrument and one that I use continually for writing in manifold. I therefore speak from a practical experience extending over a considerable period.

I believe this pen is now called the "Pelican" stylograph, by Messrs. De la Rue, the manufacturers of it, and as I have seen it being made I can testify to the great care exercised in its production.

Having now concluded my notes on stylographic pens, I should like to be permitted to assure the reader that I have throughout endeavored to obtain the most reliable information on the various details described, and I have received very valuable help from gentlemen interested in the industry, as well as from Mrs. Robinson, to whose husband I have referred more than once. It is more than probable, however, that errors may have found their way into my descriptions, in which case I shall be glad to be corrected, and to rectify any such errors. As I intimated before, I do not attempt to advocate any one pen, but simply desire to place on record what has been done by busy inventors and workers to produce a satisfactory writing implement.

I now pass on to say a few words about gold pens and their manufacture.

To adapt the quill pen to modern requirements, as a writing implement, is impossible. In use, it has charms which kept it in favor for a very long time, but the disadvantages are great. It needs continual repair and attention, and it is not given to all to make a passable quill pen. Its life is limited.

The steel pen is a great stride in advance of the quill. But a steel pen has serious drawbacks. The best steel pen will be quickly corroded by the acid found in many of our inks, or it will oxidize, and many a steel pen has to be discarded through one or other of these causes just as the writer is beginning to congratulate himself that at last he has a smooth-running pen with which he can write in comfort.

True, pens are frequently made of metals other than steel—alloys not so liable to corrosion. To meet the requirements of a good pen, such a metal must be flexible, durable, and proof against the action of corrosion and acid, and experience has proved that gold is the only metal which meets the case. It is, however, not pure gold, but is alloyed with silver, and thus reduced to 14-carat quality. This is almost universally adopted as the correct standard of fineness. There is another supreme quality required which the gold does not possess in a sufficient degree, and to obviate this defect the exceedingly hard metal iridium is called into service. The high price of iridium prohibits its use in making the complete pen of that metal; but it is recorded that about the year 1822 an English engineer, John Isaac Hawkins, discovered the advantage of attaching a fragment of iridium to the point of a gold pen, placing it in such a position on the point that it was the only part of the pen coming into contact with the paper in the process of writing. Iridium still continues to be the characteristic feature of all the best gold pens, though since Mr. Hawkins's time many improvements have been made in the methods of manufacture. Mr. Hawkins conducted a long series of experiments with a view to arrive at the best material to use. He tried rubies for the purpose, but these did not prove satisfactory. He cemented diamond dust to the points of quill pens, with even less satisfactory results.

It appears that after some thirty years of experiment, Mr. Hawkins heard of the failure of a pen-maker (Mr. Robinson) to make a pen of iridium, which he found too hard to work into shape. This fact encouraged Mr. Hawkins to give iridium a trial. The excessive hardness of the metal appealed to him, and in a simple manner he overcame the trouble. A very high speed lathe solved the problem. Using diamond dust and oil on a disk running at a very rapid rate, he found that he could cut into iridium, but even then very slowly, for a ruby could be cut in about one-third of the time. If then, iridium was say three times as hard as the ruby, he felt he had arrived at the right substance to give an absolutely durable pen point. But iridium was scarce. There was only one dealer in London at that time from whom it could be procured, and his stock was so small as to become quickly exhausted. However, there was sufficient of the precious metal to form points for a number of pens.

Thus the honor of originating the present and almost universal type of gold pen belongs to England, a trivial matter it may seem, but it has grown into an extensive industry.

It remained for our American friends to invent various labor-saving machines and devices for the production of gold pens, and although a large number are manufactured in England, it is said that New York practically supplies the bulk of the gold pens used throughout the world.

By the courtesy and kindness of Mr. Evelyn de la Rue I have recently had the opportunity of seeing gold pens manufactured in the works in Bunhill-row. I have also been given valuable information on this subject by Mr. Watts, the London representative of the well-known firm, Messrs. Mabie, Todd & Co., of New York, and I propose using by way of illustration some woodcuts with which Mr. Watts has been good enough to supply me. Without going into minute detail I would give a sketch of the various phases assumed during the process of manufacture:

Ingot of Gold.—Beginning with the brick or ingot of pure gold, the first step, of course, is to alloy this with silver and copper to a fineness of 14 carats. The alloy is melted and remelted to insure uniformity, and is then cast into ingot form. The ingots are then rolled into ribbons of a width and thickness suitable for the particular kind, or size, of pen to be afterward made from it.

Fly Press.—These ribbons are fed by hand into a fly press, the die and matrix of which, formed to the exact outline required, relentlessly cut or stamp out the "blanks" one after another as the operator swings the handle of the press, leaving the ribbon of gold as here shown, in Fig. 102. This is the birth of the gold pen, and its appearance coincides with the orifice formed in the ribbon.

Pen Blanks.—The "blank," as it is called, is shown in Fig. 103 at *C*. It is, of course, a flat piece of gold, and does not from its general form look like a promising writing implement, but it is ready to have its iridium point applied, and to this end the blank is first hollowed out on one side of the point as shown at *D*, to receive two carefully-selected particles of the hard and costly iridium, which the workman, by the aid of a strong magnifying glass, applies to the tip of the point. With a blowpipe flame the gold is fused around the iridium, and holds the grains firmly in place. This leaves the blank in the condition indicated at *E*, and is ready for the next process, which consists in passing it between rollers under a great pressure, which has the effect of elongating it considerably, as shown at *F*. The point is not touched, and the amount of rolling is regulated by the degree of elasticity required in the finished pen. Tempering is attained by the action of a steam hammer, which also solidifies the gold and improves its elasticity.

Gold Nibs.—The blank is now cut a second time by means of a punch and die, when it assumes more of the appearance of a finished pen, except that it is still flat, as at *G*. (Fig. 104.) It also has embossed or stamped upon it the maker's name or some distinguishing device, and the point—which is still clumsy and thicker than the other part, as it has not been rolled—is carefully ground away with emery wheel and oil until the iridium particles are exposed. The blank is now ready for raising or shaping into the curvilinear form shown at *H*, so familiar in pens, and this is done by a blow from a die of the correct shape, which presses the pen into form between its surface and that of a counter-die. Slitting is next accomplished by means of a thin disk of soft copper revolving at a very high speed, its periphery dipping into a reservoir of very fine emery and water, and the action of this disk as a cutting tool is so positive that not even iridium can withstand it. The pen now, as seen at *I*, is not just the instrument one would select to write with. To reduce it to proper form, it is placed in a kind of holder, which firmly grips it right up to the root of the slit, and the sawn edges of the slit are carefully ground, polished on a thin iron disk revolving in oil and emery, and it requires all the skill of an experienced workman to make these edges exactly true and alike. This being done, as at *J*, *K*, the points are just as carefully ground, and the nibs are set in their familiar position. The setting must be properly done, as if one nib of the pen should be thicker or thinner than the other, or if one should not be an exact counterpart of the other, the pen will be useless. The last process is to roughen slightly the underside of the pen point, and thus enable it to hold the ink. This is done by the action of the sand blast. The result of this is indicated at *L*, and his "nib-ship" is complete.

It may be of passing interest to state that, at the works of Messrs. De la Rue the workmen employed in making the gold pens are required to wash their hands and faces before leaving the premises, with the result that something like £150 to £200 worth of gold is recovered per annum, and it is stated that in the works of the Waterman Pen Company, in the United States, a similar rule is enforced, producing about $90 worth of gold each month. The clothing worn by the operators is the property of their employers, who burn the garments to ashes for the sake of the gold-dust they carry.

The gold nib has become the universal writing point of the fountain pen. The gold, as I have already stated, is used because of its non-liability to oxidize; and iridium is adopted because of its extreme hardness, which renders it peculiarly suitable to resist wear due to friction, as it glides over the surface of the paper. Gold pens may be had in every degree of flexibility, either with fine or broad point, and cut to any angle, so as to suit the requirements of the most fastidious, and the most exacting scribe.

(To be continued.)

THE SELECTION OF PORTLAND CEMENT FOR CONCRETE BLOCKS.*

By RICHARD K. MEADE.

IN every new industry there are some successes and many failures. The concrete block industry has been more fortunate than most new industries, in that a heavy demand for building materials of all kinds has made the number of failures less than the number of successes. Whether this condition will last will depend entirely upon the class of work done by the present generation of concrete block manufacturers. If their work is good, if their product proves sightly and buildings made of it turn out to be enduring and sanitary, the failures of the future will be few, and will depend wholly upon a disregard of the law of supply and demand, or an ignorance of the business. If the work of the present generation is poor, if buildings built of its product are unsightly, damp and given to decay and ruin, the failures of the future will be many and will, of course, be directly attributable to the poor work of the present day manufacturers.

A general impression seems to prevail that sand is of many grades and must be carefully selected to give a block of good color and the requisite strength. Likewise, that each make of concrete block machine possesses features peculiar to itself which will add to the economy with which the factory can be run or the quality of its output. Portland cement, however, is thought to be Portland cement, and, like Caesar's wife, to be beyond reproach. One brand is often considered as good as the other, and the whole matter of selection often turns on a difference in price of a few cents a barrel. A sales agent for a large cement plant recently said to me, "My friend, there is no such a thing as *bad* Portland cement," which was another way of saying that "there is a sucker born every minute," and, if a cement is not good enough for the careful purchaser who tests his purchase, it can readily be worked off on the careless man who does not.

* Paper read before the Cement Users' Association.

The concrete block manufacturer needs the best of cement, and the future of his business will depend upon his getting this. If he allows his warehouse to become the dumping ground for cement rejected for such heavy rough undertakings as piers, abutments, foundations, etc., how can he expect the finer and more exacting class of work which he does to last?

It is the purpose of this paper to point out the properties most requisite in Portland cement to be used for the manufacture of concrete blocks. Three all-important qualities of the latter will be dependent upon the cement of which they are made—two of them will be entirely dependent upon it and the third to some extent. These properties are:

(1) Endurance.
(2) Strength.
(3) Color.

The endurance of the block is, of course, an important property, as it makes little difference what strength the building may have when made if in short time it is to disintegrate. The strength of the block, however, should be such that it will withstand all stresses, strains and loads which may be applied to it, either in the laying of it in the wall or after it is in position and the building completed. The color of the block affects its marketability for superstructure work.

To take up the way of attaining these qualities in detail, we will first turn our attention to endurance.

To manufacture concrete blocks which will last, and which will retain their strength in spite of the disintegrating action of time, water and the gases of the atmosphere, a "volume constant" or "sound" Portland cement must be used. What causes certain cements to swell and expand after mixing with water and allowing them to harden is not certainly known. Those conditions surrounding the manufacture of cement which give it this tendency are well understood, however, and are usually improper proportioning of the raw material (allowing the lime to be in excess over the silica and alumina) and insufficient grinding and burning of the mixture. This has led most cement investigators to attribute disintegration to an excess of "free lime." This free lime is locked up in a case of hard cement clinker, and is almost as effectually protected from water when the cement is made into concrete as if it were sealed up in a bottle. In time, however, the hard protecting case of clinker is itself acted upon by the moisture of the atmosphere, etc., and becomes hydrated. The water then has a chance to get at the free or loosely combined lime, and this, in hydrating or combining with the water, expands with great force and disintegrates the now fully hardened concrete, just as water freezing in an inclosed vessel will burst the container, no matter what its strength may be. This is the most common explanation of the "blowing" or expanding of unsound cement, but be the reason what it may, it is a fact that such Portland cement sometimes expands to such an extent after hardening that the expansion may even be measured and blocks of concrete made from such cement will sooner or later fall to pieces and disintegrate.

Certain brands are much more liable to this tendency than others. Some mills are provided with insufficient grinding machinery for the raw materials, and can, therefore, seldom make a cement which is sound when fresh. These depend on seasoning to make their product sound, and hence, when pushed for orders, are very apt to ship fresh, and consequently, for them, unsound cement. Lack of knowledge, or of skill in manufacture, or of system in supervising the process, often is the cause of unsound cement. It is probably easier to make a sound cement from cement rock alone than from any other material, and next to this comes the cement-rock-limestone mixture, the difficulty with this growing as the percentage of limestone in the mixture increases. It usually costs less to make an unsound cement than a sound one, because less care is needed in proportioning the raw materials, less grinding is necessary to prepare them for the kilns and less coal may be employed in burning them. Consequently, the block manufacturer should exercise care in purchasing cement to make sure he does not secure cheaply or carelessly made and, consequently, often unsound cement. If he does secure such a cement, the result will be this: his blocks when freshly made and after "curing" will be sound and hard, and will present no sign of the dissolution, which may ultimately take place with them. They will go out and be laid in the wall of a house. In time, possibly in a year, maybe more, the face of the blocks will begin to crumble and strip off the blocks, cracks will appear in them, and, if the cement were very much unsound, the blocks will eventually crumble away.

Unsound cement is by no means a rare occurrence, either, and there are manufacturers who believe "no cement is bad" and ship fresh, whether it passes standard "soundness" test or not. The cement inspector of a large corporation recently told me that 90 per cent of the cement offered his concern by a certain manufacturer was rejected because of its failure to pass the soundness tests. Are you certain that you did not get any of this cement? I know that cement tests are expensive, yet I know of no better safeguard against unsound cement than the laboratory test. The next best thing is confidence in the knowledge, skill, care and good faith of the manufacturer himself. The concrete blocks made of unsound cement differ in no way perceptible to the senses from those made of sound. It may not disintegrate for years; it may, indeed, for that matter, never disintegrate, but the chances are that the blocks made of unsound cement will sooner or later crack and crumble, and the concrete block industry in the sections in which this does occur will very likely receive a serious setback thereby.

It is now generally recognized that seasoned cement is much better than fresh. My own experiments indicate that cement seasoned in bulk for about six months is at best. Cement which has been kept in bags this length of time, unless stored in a very dry place, may lump, however, and consequently the block manufacturer may have some trouble making a good sand mixture. There is much to be said in favor of the block manufacturer buying his cement in large quantities and storing the same for some months. By doing this he will be much less likely to use unsound cement, since unsound cement is often cured or made sound by seasoning. The cement will also gain some in strength. Two objections to storage are, the liability of the cement to lump or cake, and possibly in some cases of its becoming quick setting. The latter tendency is usually met with in low limed and poorly manufactured cements, though under certain conditions all cements seem liable to become quicker setting with seasoning.

It is a well known fact to those versed in the technology of Portland cement that the addition of plaster of Paris to unsound cement often makes it pass the standard steam test; and that some manufacturers make a practice of so "doctoring" unsound cement. The addition, however, is harmful to cement, as an excess of plaster not only causes the concrete to weaken in time, but also causes unsightly white streaks and efflorescence on concrete blocks. The unsoundness caused by plaster can only be detected by long time tests, so that the usual plan of guarding against it is by limiting the amount of sulphur trioxide found in the cement to 1.75 per cent. Since this is the active constituent in plaster of Paris, by determining the amount present (as can readily be done by a chemical analysis), we can calculate if a harmful percentage of plaster has been added to the cement.

While not strictly falling under the title of this paper, it may be well here to mention some causes of unsoundness in concrete blocks, which are not due to the quality of the Portland cement itself, but to qualities which are developed in it by the use of certain chemicals, etc., added to facilitate manufacture or give color. The demand for a quick setting cement has brought into use the carbonates and hydroxides of potash and soda. These chemicals are the base of nearly all the quick hardeners sold to the concrete block manufacturer. They cause unsoundness to a marked degree, and should not be used except upon the advice of an expert cement chemist. They also cause efflorescence on the block.

Some care should also be used to guard against coloring matters for the blocks which contain chemicals, such as the sulphides or sulphates, chromates, acetates, etc., likely to react with the cement to the damage of the block. Most sulphides are readily oxidized to sulphates, which change is accompanied by expansion and consequently disintegration of the block. Pure oxide colors are best, and can be used with safety. Sands with a large percentage of soda and potash minerals (such as mica) or containing pyrites (iron sulphide) are also objectionable for the reasons given above.

The strength which Portland cement may develop is due to various conditions of its manufacture, such as chemical composition, thoroughness of burning, and fineness to which it is ground. As cement is always used with sand, no attention need be paid to its neat strength unless blocks are to be faced with very rich mixtures. Neat strength is very deceptive and is seldom a reliable indication of sand strength.

One of the most important qualities of Portland cement in determining the strength of the concrete made from it is the fineness to which it is ground. Other things being equal, the finer the cement, the greater will be the strength of the concrete. Thus, a cement as ground by the manufacturer so that 95 per cent of it would pass a 100 mesh sieve, gave a sand tensile strength of 267 pounds in seven days, while the same cement ground to all pass a 200 mesh sieve gave 375 pounds for the same period, or an increase of 40 per cent in sand strength due to finer grinding.

Probably all concrete block manufacturers are striving for a waterproof block—one in which all the voids are filled. This latter may be achieved by the use of a richer mixture, by waterproofing compounds, or preferably by the employment of a sand containing the proper proportion of fine particles. These fine particles help to fill the interstices between the coarse ones and to so keep out the water. One of the oldest principles of good concrete is "to coat the particles of sand with the cement paste," and that the strength of the concrete is proportionate to the thoroughness with which this has been done. Now, the finer a body is pulverized, the more surface it will present. Thus, if we divide a cube an inch square into halves, we will increase the surface area from 6 to 8 square inches, and if we quarter it we will increase to 10 square inches, etc. Consequently, the finer the sand we use, the more surface there will be to coat and for exactly the same reason the finer must be the cement to coat this sand.

By using a sand containing fine particles and a finely ground cement in place of a richer mixture, fine cement is made directly more economical than the coarsely ground one.

By "fine cement" however, is not meant a cement ground by rolls, etc., to show a good sieve test, but a cement which contains a large percentage of flour. Since in such a dense concrete there are no voids, or practically none, there is no room left for the expansion of the cement during hardening, as is the case with ordinary porous concrete where the cement can usually expand a little into the spaces between the sand grains, and it is doubly important to use a sound, or, in other words, a non-expanding Portland cement.

The setting time of Portland cement also has an important influence on the strength. Slow setting cements, that is, cements which get their final set in from 4 to 9 hours, are much stronger than those which set more quickly. Quick setting cements are nearly always overclayed, and contain less of the active silicate and aluminate of lime, to which cement owes its strength, than the slower setting ones. This may seem paradoxical, but is nevertheless true. The compounds in cement which set quickly are not those which give it great strength, consequently cements giving an initial set of less than 30 minutes are hardly ever as strong as those which require from 2 to 3 hours. For example, a cement which sets in 30 minutes rarely ever, unless very finely ground, gives a 7-day sand test of over 250 pounds, while one with a set of 2 or 3 hours may easily give 300 to 350 pounds, or even more. Cements with a "flash" set, that is, which set up under the trowel, should not be used in making blocks, as these latter are apt to be weak. With such cements the set is broken by working, the processes of solution and crystallization are interfered with, and consequently have only half a chance to do their work. The set of the cement should always be sufficient to give ample time to mix the mortar and fill the machine, or molds.

One of the greatest requisites of Portland cement to be used for concrete blocks is that it shall be a quick hardener. It must get its strength promptly. By prompt hardening is not meant quick setting cement. The term "set" is merely used to define the change undergone by the mortar in passing from the plastic to the solid state. The hardening only begins after the setting process is completed, and quick setting cements are not necessarily prompt hardeners, and are, indeed, usually the reverse.

The best test for prompt hardening is the 7-day sand strength. Cements which get a tensile strength of 300-350 pounds per square inch in 7 days are now on the market, and these are best suited to concrete block manufacture. If the blocks do not lose strength, the sooner they get their full strength the better, because the sooner they can be used, as less time is needed to cure them. A cement which has a sand strength of 350 pounds after 7 days, and which has only increased 50 pounds in a year, is, to my mind, much better for the purpose than one which has a strength of 200 pounds at 7 days and increased 150 pounds in the same length of time; because it will stand the same stress seven days after making that the other one will after it is a year old. A building may have to bear its full load three months after the blocks are made, and hence the prompter hardening cements are needed for block making.

Concrete blocks are now sometimes waterproofed by coating their exposed surface with a thin layer of paraffine. This thin layer effectually protects the interior of the block from the moisture of the air, and as cement cannot gain in strength after it is so coated, consequently, where waterproof blocks are made, prompt hardening cements should be used, and the block should be allowed to gain good strength before applying the coating. For a similar reason these blocks should not be made too dry.

The concrete block manufacturer will probably be more interested in the color of his blocks than in any other one of their properties, since upon this will depend the immediate marketing of his product. Uniformity of color is, therefore, very important to him, since the color of a building, in order to be pleasing, should present a uniform appearance to the eye. Uniformity can only be secured by making the block of uniform cement and sand mixed in definite proportions and manufactured into blocks under as nearly the same conditions as it is possible to obtain. For coloring blocks, dark colored cements may be used but their color should be uniform. For lighter blocks, light colored cements must be used. As the color of cement gets lighter as it is ground finer, only finely ground cements should be employed for this work. The percentage of iron and manganese in the cement also influences the color. Cements free from iron and manganese would be white, and the color darkens as the percentage of iron or manganese increases. Most cements are practically free from manganese, and hence the color is usually due to iron.

Sulphate of lime, which is always added to cement to regulate the set, is one of the causes of the white efflorescence seen on concrete blocks. This salt is soluble and is carried to the surface of the block by the water which "sweats" out during curing. The less sulphate of lime present in cement intended for concrete block manufacture, the better. As Portland cement can be obtained which contains less than 1.5 per cent sulphuric trioxide (the chief constituent of the sulphates and the way they are usually reported in a chemical analysis), it is hard to see why cement containing more than this amount should be used.

The alkalies are also soluble salts, and are to some extent responsible for the saline efflorescence on concrete. Cements low in these should, therefore, be used. Most American Portland cements, however, contain less than 1 per cent alkalies.

Sulphide of iron is sometimes met with in cements burned in upright kilns. This causes dirty brown splotches to appear in the work from the oxidation of the iron to brown oxide of iron or "rust." Overclayed cements also show the same dirty brown color throughout the mass, as in such cements the iron seems to be present as the red brown "sesquioxide" instead of the black "magnetic" oxide of well made cements.

[Concluded from SUPPLEMENT No. 1582, page 25330.]

LIGHTNING AND THE ELECTRICITY OF THE AIR.—III.*

By ALEXANDER G. McADIE.

ERECTION OF RODS—GENERAL DIRECTIONS.

1. Few questions have been so thoroughly discussed from practical as well as theoretical standpoints as that of the certainty of the protection afforded by properly constructed lightning rods. Ordinary dwelling houses in city blocks have not the need for rods that scattered houses in the country, and especially if on hillsides, have.

2. Use a good iron or copper conductor. If the latter, one weighing about six ounces to the foot, and preferably in the form of tape. If iron is used, and it seems to be in every way as efficient as copper, have it in rod or tape form and weighing about thirty-five ounces to the foot. "A sheet of copper constitutes a conductive path for the discharge from a lightning stroke much less impeded by self-induction than the same quantity of copper in a more condensed form," whether tabular or solid.—Sir William Thomson.

3. The nature of the locality will determine to a great degree the need of a rod. Places apart but a few miles will differ greatly in the relative frequency of flashes. In some localities the erection of a rod is imperative; in others hardly necessary.

4. The very best ground you can get is, after all, for some flashes but a very poor one; therefore do not imagine that you can overdo the matter in the making of a good ground. For a great many flashes an ordinary ground suffices, but the small resistance 1-10 ohm for an intense oscillatory flash may be dangerous. Bury the earth plates in damp earth or running water.

5. "If the conductor at any part of the course goes near water or gas mains, it is best to connect it to them. Wherever one metal ramification approaches another, it is best to connect them metallically. The neighborhood of small-bore fusible gas pipes and indoor gas pipes in general should be avoided."—Lodge.

6. The top of a rod should be plated or in some way protected from corrosion and rust.

7. Independent grounds are preferable to water and gas mains.

8. Clusters of points or groups of two or three along the ridge rod are recommended.

9. Chain or linked conductors are of little use.

10. Area of protection. Very little faith is to be placed in the so-called area of protection. The committee that first gave authority to this belief considered that the area protected by one rod was one with a radius equal to twice the height of the conductor from the ground. Many lightning rod manufacturers consider that the rod protects an area of radius equal to the height. The truth is that buildings are struck sometimes within this very area, and we now hold there is no such thing as a definite protected area.

11. Return shock. Some uncertainty exists on this point. The so-called "return stroke" is caused by the inductive action of the charged cloud on bodies within its influence, and yet some distance away from the place of the direct charge. As explained by Lord Mahon, who first called attention thereto, the sudden return of the body charged inductively to a neutral condition, following the equalization at some distant place, is the cause of the return shock. We are beginning, however, to see more clearly into the character of the stress in the dielectric, preceding and during flashes, and it is only a question of time before the use of this term, "return shock," will be abandoned. Of far greater import are the terms "recoil kick" and "alternate path," as shown experimentally by Lodge to exist.

12. Upward motion of stroke. There is no reason to doubt that the discharge takes place sometimes from earth to cloud. That is to say, that while we now consider a lightning flash as something like the discharge of a condenser through its own dielectric, made up of excessively frequent alternations say something like 300,000 times per second, the spark, or core of incandescent air, may seem to have had its beginning at the earth's surface. That is to say, the air gap breaks down first at a point near the earth.

13. Indifference of lightning to the path of least resistance. Nearly all treatises upon lightning up to within very recent times, assumed that lightning always followed the path of least resistance. "It is simply hopeless to pretend to be able," says Lodge, "to make the lightning conductor so much the easier path that all others are out of the question." The path will depend largely upon the character of the flash.

14. Any part of a building, if the flash be of a certain character, may be struck whether there is a rod on the building or not. Fortunately, these are exceptional instances. The great majority of flashes in our latitudes are not so intense but that a good lightning rod, well earthed, makes the most natural path for the flash We have many instances, however (not to be confounded with cases of defective rods), where edifices, seemingly well protected, have been struck below the rods.

15. Paradox of paradoxes, a building may be seriously damaged by lightning *without having been struck at all*. Take the famous Hotel de Ville of Brussels. This building was so well protected that scientific men pronounced it the best protected building in the world against lightning. Yet it was damaged by fire caused by a small induced spark near escaping gas. During the thunderstorm, some one flash started "surgings" in a piece of metal not connected in any way with the protective train of metal. The building probably did not receive even a side flash. This is, therefore, a new source of danger from within, and but emphasizes the necessity of connecting metal with the rod system.

16. Lightning does sometimes strike twice in the same place. Whoever studies the effects of lightning's action, especially severe cases, is almost tempted to remark that there is often but little left for the lightning to strike. No good reason is known why a place that has once been struck may not be struck again. There are many cases on record supporting the assertion.

17. As lightning often falls indiscriminately upon tree, rock, or building, it will make but little difference sometimes whether trees are higher than adjoining buildings.

18. It is not judicious to stand under trees during thunderstorms, in the doorway of barns, close to cattle, or near chimneys and fireplaces. On the other hand, there is not much sense in going to bed or trying to insulate one's self in feather beds. Small articles of steel also do not have the power to *attract* lightning, as it is popularly put, or determine the path of discharge.

19. Unnecessary alarm. Just in advance of thunderstorms, whether because of the varying electrical potential of the air or of the changing conditions of temperature, humidity, and pressure, and failure of the nervous organization to respond quickly, or to whatever cause it may be due, it cannot be denied that there is much suffering from depression, etc., at these times. It is, perhaps, possible that these sufferings may be alleviated. Apart from this, many people suffer greatly from alarm during the prevalence of thunderstorms, somewhat unnecessarily, we think. Grant even that the lightning is going to strike close in your vicinity. There are many flashes that are of less intensity than we imagine, discharges that the human body could withstand without permanent serious effects. Voltaire's caustic witticism that "there are some great lords which it does not do to approach too closely, and lightning is one of these," needs a

* Reprinted from Journal of Electricity, Power and Gas.

EFFECT OF LIGHTNING STROKE ON A WALNUT TREE.

EFFECT OF LIGHTNING STROKE ON AN OAK.

Photographed by A. J. Henry.

little revision in these days of high potential oscillatory currents. Indeed, the other saying, "Heaven has more thunders to alarm than thunders to punish," has just so much more point to it, as it is nearer the truth. One who lives to see the lightning flash need not concern himself much about the possibility of personal injury from that flash.

20. Finally, if you should be in the vicinity of a person who has just been struck by lightning, no matter if the person struck appears to be dead, go to work at once and try to restore consciousness. There are many cases on record proving the wisdom of this course; and there is reason for believing that lightning often brings about suspended animation rather than somatic death. Try to stimulate the respiration and circulation. Do not cease in the effort to restore animation in less than one hour's time. For an excellent illustration of a case of severe lightning shock and recovery, due, it would seem, to prompt action by the medical gentlemen present, all who are interested may consult the Medical News, August 11, 1888. A number of cases corroborative of this view are on record in various medical journals.

No matter what method for respiration you use, it is important to maintain the warmth of the body by the application of hot flannels, bottles of hot water, hot bricks, warm clothing taken from bystanders, etc.

Firmly and energetically rub the limbs upward, so as to force the blood to the heart and brain. If an assistant is present let him attend to this. Remember above all things that nothing must interrupt your efforts to restore breathing.

When swallowing is established a teaspoonful of warm water, wine, diluted whisky, or warm coffee should be given. Sleep should be encouraged. In brief:

1. Make the subject breathe by artificially imitating the respiratory movements of the chest.
2. Keep body warm.
3. Send for a physician.

Of the visible effects of lightning stroke upon the human body little more can be said than that sometimes burns, usually superficial, have been noticed, frequently red lines and markings, which are localized congestions of the small blood vessels of the skin. These, from their irregularities and branchings, have led to the fanciful idea of photographs of trees, etc.

In conclusion it may be said that lightning frequently causes a temporary paralysis of the respiration and heart beat which, if left alone, will deepen into death, but, intelligently treated, will generally result in recovery.

LIGHTNING ARRESTERS.

In his "Experimental Researches,"* Faraday describes the miniature house he had built to test the question of shielding bodies from electrical influences without. It was a hollow cube twelve feet high, wound around completely on the outside with wire. He says:

"I went into this house and lived in it; but though I used lighted candles, electrometers, and all other tests of electrical states, I could not find the least influence upon them or indication of anything particular given by them, though all the time the outside of the cube was powerfully charged and the large sparks and brushes were starting off from every point of its outer surface."

Maxwell, in 1876, suggested to the British Association a plan, based on the experiments of Faraday, for protecting a building from the effects of lightning by surrounding it with a cage of wire or rods. The problems which the electrical engineers of to-day are called upon to solve are different from those of the time of Faraday or even Maxwell. Extensive light and power plants must be guarded with great thoroughness. Cables and telegraph lines have for years been provided with various forms of lightning arresters, but only in the past few years has the action of lightning been studied with some degree of success. The chief function of all of the old-style lightning arresters has been to sidetrack the flash, switching it out of the main circuit and leading it as quickly as possible to earth. Cable, telephone, and telegraph line protection have been systematically studied of late years by Prof. Oliver L. Lodge and others. In Lodge's excellent book upon lightning conductors and lightning guards the theory of lightning arresters is given at length. Satisfactory apparatus has been devised upon sound scientific principles for the protection of the delicate galvanometers and other instruments employed on cable, telephone, and telegraph lines. The principle applied may be stated in general terms to be "a succession of air-gap paths to earth, connected up by coils of well insulated wire, across the turns of which the lightning, weakened as it is by the first air gap to earth, is not able to leap."†

In protecting electric light and power plants, there is the further and very important question of preventing the formation of an arc across the air gaps or at any point on the circuit, thus short-circuiting these heavy currents. Many devices exist for automatically rupturing the dynamo arc thus formed. Some have many points of excellence, but the ideal protector must not only give a proper spark gap and also rupture any arc that may form, but better still should be so designed as to prevent the formation of an arc.

Alexander J. Wurts has for many years studied the problem of protecting electrical apparatus with a great measure of success. It is known that discharges do not pass readily through coils of wire, and Wurts has found that properly constructed choke coils connected in the circuit and used with arresters form a good combination for protecting against lightning. While experimenting along these lines Wurts discovered that if the electrodes of an arrester were made of zinc the short-circuiting arc would not be maintained. There are five metals—zinc, bismuth, antimony, cadmium, and mercury—which are non-arcing metals. For alternating currents these non-arcing arresters are quite reliable. For direct-current circuits an arrester is used in which the high-potential discharge is made to pass over a circuit discharge plane, e. g., a pencil line upon a block of marble, and by means of a second block firmly bound to the first, the vapors from the electrodes, upon which the arc feeds, are suppressed. Wood is now used instead of marble, as at first, and shallow grooves take the place of the pencil line. It is also necessary to slot the upper block at right angles. This arrester is also a discriminating arrester, in that it allows disruptive charges to pass freely, but does not allow a dynamo current to follow. These are the points dwelt upon by Wurts in a lecture given before the Franklin Institute in June, 1905.

FUNDAMENTAL PRINCIPLES OF THE NON-ARCING RAILWAY LIGHTNING ARRESTER.

The fundamental principles of this device are based on the following facts:

1. That a static discharge will leap over a non-conducting surface, such as glass, wood, marble, etc., more easily than through an equal air space. If a pencil mark be drawn over this non-conducting surface the discharge will take place still more readily.

2. That a dynamo arc in order to be maintained must be fed by the fumes or vapors of its electrodes—conversely, therefore, that in order to avoid the formation of a dynamo arc between electrodes means must be taken to prevent the formation of these conducting fumes.

The Electric Crack.—An electric spark which springs across an air gap does not pass like ordinary moving matter gently pushing the air aside. Its passage is so instantaneous that the air is shattered, so to speak; the spark crashes its way through the air like a bullet through a pane of glass. If, however, the air be previously split—electrically split—the spark will pass with ease. A pencil mark over ground glass or a charred groove in a wooden surface forms an electrical crack or entering wedge through the air so that an electric discharge finds a much easier path over this surface and through this electrical crack than it does when it is forced to bore its own way through the air medium.

Discharge by Disruption.—In the non-arcing railway lightning arrester the discharge is caused to pass between two brass electrodes separated by half an inch and over narrow grooves burned into a block of lignum vitæ. It must not be understood that this charred surface acts as a conductor in the ordinary sense of the word. The discharge takes place not by conduction, but by disruption, leaping between the electrodes and over the charred surface, the latter acting simply as an electrical crack through the air and thus greatly assisting the passage of the electrical discharge; neither does this charred surface leak dynamo current, for the ohmic resistance between the electrodes is more than 50,000 ohms. If now a solid lignum vitæ block be firmly screwed down over the charred grooves and metal electrodes it will be impossible for conducting vapors to form and the device is at once a non-arcing lightning arrester.

CHOKE COILS FOR ALTERNATING-CURRENT CIRCUITS.

A lightning discharge is of an oscillatory character and possesses the property of self-induction; it consequently passes with difficulty through coils of wire. Moreover, the frequency of oscillation of a lightning discharge being much greater than that of commercial alternating currents, a coil can readily be constructed which will offer a relatively high resistance to the passage of lightning and at the same time allow free passage to all ordinary electric currents.

Any coil will afford a certain amount of impedance to a disruptive discharge. Experience has shown, however, that there is one form which offers at once the maximum impedance to the discharge with the minimum resistance to the generator current.

Choke coils of this type connected in the circuit, when used in connection with non-arcing lightning arresters, offer a very reliable means of protecting well insulated apparatus against lightning. This arrangement is particularly well suited for protecting station apparatus in power transmission systems. Coils can, however, be used to advantage on the line for the protection of the more expensive translating devices.

Tests made under actual working conditions indicate that for ordinary commercial voltages effective protection is obtained with four choke coils in series in each wire, with four lightning arresters intervening.

BURR OAK SHATTERED BY LIGHTNING.

Photographed by Frank Woodmancy.

LIQUID CRYSTALS.

THE terms "liquid crystals" and "crystalline liquids," which are not infrequently to be met in scientific journals, have been criticised as paradoxical. But there is some justification for their use, though we do not wish to imply that the matter has passed out of the controversial stage. In 1888 Reinitzer observed that cholesteryl benzoate, at ordinary temperature forming beautiful colorless crystals, melts at 145.5 deg. C. to a turbid oily liquid, which becomes clear at 178.5 deg. The oily phase proved doubly refracting; the clear phase allowed light to pass like an ordinary liquid, which should, of course, not have any properties indicating a structural grouping about certain axes, as this crystalline liquid did.

The optical anomalies of this and similar substances have specially been studied by O. Lehmann, of Karlsruhe. The ethylester of the para-oxybenzoic acid afforded the first example of flowing or liquid crystals. When Vorländer melted this substance, and added small quantities of certain other substances to it, there were deposited long needles of this ester, which displayed dichroism in polarized light—i.e., appeared in different colors when viewed in different directions—but were uniaxial. They possessed other peculiarities which would not be striking in ordinary crystals. But these crystals display some strange properties. They are soft, and can easily be deformed by gentle pressure; their edges are not well defined; two needles, approached to one another, coalesce to one; when an air bubble settles on one of the broad sides, nothing noteworthy happens; when the air bubble settles on the point, the needle seems to grow into the bubble, and a kind of pyramidic point with curved faces is formed. Evidently surface tension still plays an important part in the semi-liquid crystals, especially at their points.

Meanwhile Gattermann had observed that para-azo oxyanisol also melted to a turbid liquid. The spherical drops of this liquid are perfectly clear in themselves, and they only appear turbid for the same reason that aggregates of colorless crystals appear opaque. But these drops distinctly show evidence of a strange structure. The refractive index varies with the direction of the ray. The drops appear different in different positions. In what may be called the one main position there is seen a dark center surrounded by a grayish zone; in the other main position the drops look as

* Paragraph 1173.

† "Lightning Conductors and Lightning Guards," p. 419.

if they each contained a lens. In a magnetic field whose lines of force are at right angles to the microscopic stage, the drops assume the first position. In polarized light dark crosses are seen, and when the drops are rotated, those crosses become spirally twisted. At a certain temperature these peculiarities vanish, and we obtain optically simple, isotropic liquids, without any trace of double refraction. We have therefore a characteristic clarifying point in addition to the ordinary melting point.

More than twenty of such bodies are now known. They are almost all organic substances, but they do not, to the chemist, represent any special type of compound. The silver iodide, familiar to all photographers as an amorphous substance, also forms semi-liquid tough crystals. The twenty odd substances show a gradation of properties. When we arrange them as to viscosity, we find that the cholesteryl benzoate is very viscous—as much as olive oil, the viscosity being about 800, when water is 100—the anisol mentioned has the viscosity 140, the para-azo oxyphenetol the viscosity 70. The viscosity determinations are not very concordant, as critics have not failed to point out. But the bodies certainly differ strongly as to viscosity, and O. Lehmann and R. Schenck, of Marburg, the two chief advocates of the hypothesis which regards these substances as aggregates of doubly refracting, flowing or liquid crystals, have expressed the opinion that we have in these substances, as well as in the soft pliable crystals of camphor and in the yellow phosphorus, intermediate stages between the liquid and the solid crystalline state.

The reader may already have made up his mind that these substances are either not pure, or that they are not homogeneous. The former objection has been disproved. The latter has been raised by notable scientists. Quincke and Tammann have suggested that the turbid solutions are either emulsions or solutions in which solid crystals float. The suggestion sounds very reasonable, but certain observations are hard to explain on these grounds. There is something strange about the clarifying point. In the case of the para-azo oxyanisol, for instance, the density, which decreases steadily on heating, drops suddenly when that point, about 133 deg. C., is reached; and the viscosity, which likewise diminishes on heating, increases suddenly at the same temperature by nearly 50 per cent., and decreases again afterward. Such discontinuities are not shown by emulsions, and if we had to deal with emulsions, we ought to be able to separate the two different constituents in some way. All such attempts have, however, failed, or left the problem undecided. This latter remark applies, for instance, to electric osmosis or kataphoresis; the electric current generally sifts substances to a certain extent, but Bredig, Schukowsky, and Coehn have each in his turn failed to effect any kataphoresis of these bodies.

Tammann has recently formulated three chief objections. The double refraction is only apparent, he says, and caused by something like dust in the liquid, which adheres to the cover-glass, so that the refraction is not disturbed when the liquid is moved. Lehmann has established, however, that in this experiment Tammann had undoubtedly worked with impure substances. The black crosses, Tammann further points out, can be seen when air bubbles get into substances like Canada balsam. Lehmann's reply is that emulsions can never show the described phenomena. Finally, Tammann asserts that real discontinuity is very difficult to prove, and that liquid crystals would be incompatible with the theory of diffraction. That would apparently be a crucial objection. But the advocates of the liquid crystals rely on the electron theory of matter, which could also account for the fact that motion of the drops does not affect their double refraction.

There would thus appear to be some reason for suspending judgment concerning the liquid crystals. We will only add that the substances mentioned are commercial articles, and that the problems are engaging the attention of some of our scientists.—Engineering.

EXPERIMENTS WITH A LAMP CHIMNEY.

IN order that a phenomenon shall not be masked by the experimental apparatus which serves to produce it, the latter must be simple and formed of common material; furthermore, the same material should be made to serve for as many experiments as possible.

A long, thick, and truly cylindrical lamp chimney, like the chimney of a thirty-hole Bengel gas burner, or, in default of this, a eudiometer tube cut to a convenient length, offers, when completed by the addition of sundry rudimentary and inexpensive parts, means of performing a great variety of lecture experiments which have hitherto required various distinct and costly pieces of apparatus.

1. Pressure in the Interior of a Liquid.—One end of the lamp chimney is made smooth by grinding it, with emery and oil, on a perfectly plane glass plate. Then a disk of diameter approximately equal to the external diameter of the tube is cut from an old calendar or other stiff card and a thread is attached to the center of the disk with sealing wax. Thus is obtained the apparatus for the demonstration of upward pressure (Fig. 1) for which instrument makers charge 10 francs ($2).

2. Capillary Elevation and Depression.—One end of the lamp chimney is closed with a sound, fine-grained cork, a hole in which tightly fits a capillary tube bent twice at right angles. The lamp chimney being clamped in a vertical position, mercury or colored water is poured into it and the difference in level of the liquid in the two tubes is measured with the aid of a short scale placed between them. This arrangement (Fig. 2) is a substitute for the communicating vessels mounted on a board for the study of capillarity.

3. Hydraulic Tourniquet.—Two glass tubes bent into appropriate form pass through a cork which hermetically closes one end of the lamp chimney. The other end is stopped by a second cork provided with a screw-eye to which a silk thread is attached, and also with

FIG. 1.

FIG. 2.

an air hole which can be closed temporarily with a glass stirring rod. The other end of the thread having been fastened to a gallows-like support and the first cork removed, the lamp chimney is turned up, completely filled with water, re-corked and allowed to hang as in the illustration (Fig. 3). The apparatus begins to rotate as soon as the stirrer is removed from the air hole. In official catalogues the price of the hydraulic tourniquet is 52 francs ($10.40).

4. Aspirator.—Fig. 4 shows the arrangement described by M. Bombois [in the first volume of this

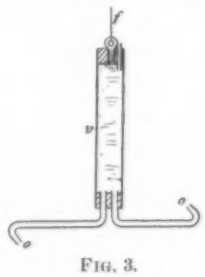


FIG. 3.

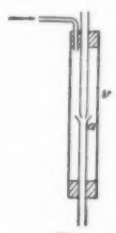


FIG. 4.

journal]. It is composed of a lamp chimney, two rubber stoppers and three glass tubes of suitable forms. A partial vacuum of 30 centimeters (12 inches) of mercury is obtained without difficulty.

5. Intermittent Siphon.—The lamp chimney, clamped in a vertical position, is closed below by a cork through which the longer leg of a little siphon passes, and above by another cork which is traversed by the stem of a small funnel, the flow of which must be less than that of the siphon (Fig. 5). The experiment is performed as with the vase of Tantalus, which costs 3 francs (60 cents).

FIG. 5.

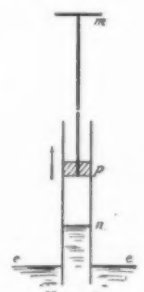


FIG. 6.

FIG. 7.

6. Ascent of Liquids in Exhausted Tubes.—For this and the following experiments it is necessary to construct a piston which shall fit the lamp chimney exactly and yet move in it with very little friction. For this purpose a disk of hardwood, with a grooved edge, is turned on a lathe. The groove is wound with paraffined cord, and a metal rod, with a cross-piece or handle at its free end, is screwed into the disk at the center.

To show the ascent of liquids in pumps the piston is pushed down to about the middle of the lamp chim-

FIG. 8.

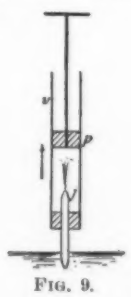


FIG. 9.

ney. Then the latter is held vertically with its lower end dipping into the liquid and the piston is drawn up. The liquid rises in consequence of the atmospheric pressure exerted on its free surface (Fig. 6).

7. Compressibility of Gases.—By closing one end of the lamp chimney with a *tapering* cork it may be converted into an inexpensive pneumatic syringe. In demonstrating the compressibility of gases the tube is held upright with the cork resting on the table.

8. The Bursting Bladder.—The experiment of the bursting bladder may be performed without the aid of the air pump. The piston is first pressed down nearly to the bottom of the lamp chimney; then a thin sheet of caoutchouc (a piece of a toy hydrogen balloon) is tied securely over the end of the tube and the piston is drawn up rapidly. The rubber is ruptured by the excess of pressure on its outer face (Fig. 7).

9. Expansive Force of Gases.—The experiment of the collapsed bladder inflated *in vacuo* may also be repeated without the aid of the air pump. The piston having been forced down about three-fourths of the length of the lamp chimney, the latter is inverted. Into the open end, which is now uppermost, is dropped a scrap of toy balloon or other sheet rubber, tied securely into a tiny bag which imprisons a little air. The tube is then tightly corked and again inverted and the piston is raised. The bag expands and sometimes bursts (Fig. 8).

10. Fountain *in Vacuo*.—The classical apparatus of the fountain *in vacuo*, which costs 30 francs ($6) and cannot be used without the air pump, may be relaced by the lamp chimney and piston. All that is necessary is to push down the piston through about four-fifths of the length of the tube, and then to close the free end of the latter with a tight tapering cork into which is fitted, *very tightly*, a small tube which has been drawn out to a fine point at each end. After the outer end of the small tube has been sealed by fusing in a flame the lamp chimney is grasped with the left hand and held erect with the closed end of the small tube under water and the piston is suddenly raised with the right hand (Fig. 9). The apparatus is held rigidly in this position while an assistant breaks off the tip of the sealed tube under water, with pincers. The fountain at once begins to play.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

THE RENOVATION OF WORN-OUT SOILS.

IN order to understand the methods necessary for restoring worn-out soils, Mr. W. J. Spillman, of the Department of Agriculture, has recently published in one of the department's bulletins the principles which underlie the renovation of exhausted soils. In order to consider what occurs in a fertile soil that is growing a large crop he asks us to imagine a cubic inch of ordinary field soil magnified into a cubic mile. It would then present very much the appearance of a mass of rocks varying from the size of a pea to masses several feet in diameter. Scattered among these rock masses would be many pieces of decaying plant roots and other organic matter, resembling rotting logs in a mass of stones and gravel. The masses of organic matter would be found to contain large quantities of water, and to somewhat resemble wet sponges, while every mass of rock would have a layer of water covering its surface. The open spaces between the solid masses would be filled with air.

If a crop were growing on this soil, its roots would be found threading their way among the masses of rock and decaying roots, and pushing these aside by the pressure exerted by the growing root. From the surface of the growing root, near its tip, small hollow threads (the root hairs) extend into the open spaces and suck up the water covering the rock particles. The root hairs are not open at the end; they absorb the water through their walls. The plant food is dissolved in this water, but is usually present in exceedingly small quantities. While the plant is growing a constant stream of water flows up through it and evaporates at its leaves. For every pound of growth in dry matter made by the plant, from 300 to 800 pounds of water flow up through it.

The plant food substances dissolved in the soil water may be divided into two classes according to their ultimate source—mineral and nitrogen compounds. The mineral plant foods are phosphorus, potassium, calcium, magnesium, sodium, iron, silicon, chlorin, and sulphur. The amount of plant food made ready for plant use during each growing season through the slow solution of the mineral particles of the soil is doubtless supplemented to a considerable degree by the same kinds of material set free from the organic matter also found in the soil—that is, the mineral matter originally secured from the dissolved minerals, but built into plants during some former season, may again be used by other plants when the old matter is given an opportunity to decay in the soil. These foods derived directly from the mineral matter of the soil and indirectly from it through the growth, death, decay, and return of former crops are also supplemented in many cases by the application of mineral matter in the form of commercial fertilizers.

In addition to the nine elements already mentioned, the growing plant requires four other elements, as follows: Hydrogen, which it secures from water (water is a compound of hydrogen and oxygen); oxygen, which it secures partly from water and partly from the air; carbon, which is secured from carbonic-acid gas in the air; and nitrogen.

Nitrogen is in many respects the most important of all the plant-food elements. It is not found in appreciable quantities in the rock particles of the soil. Ordinary plants depend for their nitrogen entirely on decaying organic matter. As decay proceeds nitrates are formed from the nitrogen contained in organic matter. The nitrates are exceedingly soluble, and unless soon made use of by growing crops they are washed out of the soil. Nitrogen is therefore usually the first element to become exhausted in the soil.

Fortunately, there are certain species of bacteria that can use atmospheric nitrogen, of which there is

an inexhaustible supply. One family of plants—the legumes—has learned to exchange work with these bacteria, and these plants are thus easily supplied with an abundance of nitrogen in a form they can use. When these nitrogen-fixing bacteria are present in a soil on which a leguminous crop is growing, the bacteria invade the roots of the legume and live there. Their presence is usually made manifest by swellings—the so-called tubercles—on the roots of thrifty plants of clover, alfalfa, beans, peas, and other legumes. Nitrogen from the soil air filters into the roots, where the bacteria appropriate it, manufacture an abundance of nitrates, and give a portion to the plant in exchange for starch. The tissues of leguminous plants become very rich in nitrogenous compounds, and when they decay in the soil they set free large amounts of nitrates for the use of any crop which may be growing at the time.

The cultivation of leguminous crops is one of the most important and economical means of maintaining a supply of nitrogenous plant food in the soil. Nitrates may, of course, be supplied in commercial fertilizers; but fertilizers containing nitrogen are very expensive, and it usually pays better to supply nitrogen by growing legumes or by the application of stable manure, which is rich in nitrogen when properly handled. In good farm practice both stable manure and leguminous crops are used as sources of nitrogen.

In order to produce a ton of dry hay on an acre of land it is necessary that the growing grass pump up from that acre approximately 500 tons of water. In order to supply this enormous quantity of water, the soil must not only be in condition to absorb and hold water well, but it must be porous enough to permit water to flow freely from soil grain to soil grain. The presence of large quantities of decaying organic matter (humus) adds enormously to the water-holding capacity of the soil. One ton of humus will absorb two tons of water, and give it up readily to growing crops. Not only that, but the shrinkage of the particles of decaying organic matter and the consequent loosening of soil grains keep the soil open and porous.

Furthermore, humus of good quality is exceedingly rich in both nitrogen and mineral plant food. The maintenance of fertility may almost be said to consist in keeping the soil well supplied with humus. The first step in renovating worn-out soils is to give them an abundant supply of humus of good quality. Perhaps the best source of humus is stable manure containing both the liquid and the solid excrement, especially when the stock are fed rich nitrogenous foods. Even a poor quality of barnyard manure, which has had much of the plant food leached out of it, has considerable value because of the humus it makes.

Another cheap and valuable source of humus, but one which must be used understandingly, is crops grown to turn under as manure. The legumes are especially valuable for this purpose because of the nitrogen they contain, but other crops, such as rye, and even corn sown thick, may sometimes be made to supply large quantities of humus of fair quality. Crops thus used are called green manures. They are more fully discussed farther on.

A proper circulation of air in the soil is just as important as any other factor of plant growth. Nearly half of the volume of ordinary soils is occupied by air spaces. The air spaces in the soil wind in and out between the soil particles, just as they do in a pile of larger stones. If the layer of water on the surface of the soil grains becomes so thick as to stop the air passages here and there the soil is then too wet for most crops and needs drainage. Plants have no special breathing organs, the oxygen required in their breathing finding entrance all over the surface of the plant. Plant roots must therefore be supplied with air, and hence the soil must be porous enough to permit of free circulation of air. A good supply of humus and proper tillage will accomplish this result in clay soils. Sandy soils are usually too porous, needing humus to help them retain water.

Another reason why air must circulate freely in the soil is that large quantities of oxygen are required to insure proper decay of organic matter to supply plant food. Also, carbonic-acid gas is produced by the decay of organic matter, and this must escape easily to make room for the atmospheric oxygen needed in the soil. The movement of air in the soil is frequently shown by the bubbles which appear at the surface of the soil just after a hard rain. As the water soaks into the soil it drives the air out, and bubbles may be seen at the surface if water enough is present to form them.

One of the most important objects of plowing is to loosen up the soil and mix fresh air with it.

Considerable evidence has been accumulated during recent years to show that the cause of the failure of some soils to produce satisfactory crops may be ascribed to unfavorable conditions produced in the soils by the plants themselves. It is thought that during the growth of the plant certain unknown organic substances are given off which, when they accumulate in the soil to any extent, are harmful to the further growth of plants of the kind that produced them. It is possible that some of the benefits known to arise from systematic crop rotation may be explained on this basis. These harmful substances seem to be disposed of rapidly by certain soils, usually those in which organic matter is readily converted into humus. Other soils, usually marked by a lack of the brown carbonized organic matter, do not seem to possess this property of removing harmful plant products to such a degree. This idea is in accord with the common experience that dark-colored soils, well filled with organic matter, are usually very productive.

In connection with the study of these poisonous organic products, it has been found that they may be destroyed or at least rendered harmless in a variety of ways. Barnyard manure or decaying organic matter, such as a green crop of rye or cowpeas, turned under has a very marked effect in freeing the soil from them. Almost all of the common commercial fertilizing materials act more or less in the same way. Commercial fertilizers for soil improvement have, therefore, another value besides adding plant food. Thorough and complete airing of the soil will often destroy or overcome these poisonous substances. The beneficial effects of plowing and of thorough surface tillage are thus explained, in part at least, on the basis of the thorough aeration secured. When the same crop is not grown oftener than every three or four years on the same land the injurious substances a crop throws off seem to have time to disappear before the same crop is grown again; hence the benefit from crop rotation. When the soil is well supplied with humus there is seldom any trouble from this source, and the same crop may be grown year after year with good yields, though continuous cultivation of the same crop may invite injury from certain insects and fungous diseases which live over in the soil or in the remains of the crop.

Improper methods of tillage add very greatly to the evil effects that result from lack of humus. In many parts of the country the land is plowed only 3 or 4 inches deep. Below the plowed stratum the soil becomes sour, densely packed, and unfit for plant roots. When such soils are plowed deep and this sour packed subsoil is mixed with the upper portion, the growth of many crops is greatly retarded. This has led many farmers to believe that deep plowing is ruinous. Some farmers have tried to remedy the difficulty by subsoiling. The subsoil plow breaks up the packed layer but does not throw it out on top. But while subsoiling does break up the hard layer into chunks it does not pulverize it or put humus into it. In most cases work done in subsoiling is practically wasted, and it is doubtful if it ever pays. A much better method is to plow a little deeper each year until a depth of 8 or 10 inches is reached. This gives a deep layer of good soil, particularly if the supply of humus is kept up.

When new soil, or that which has lain undisturbed for several years, is broken up, it is always best to plow deep from the beginning, for the deeper layers will be about as fertile as any, except the top inch or two. It is wise, too, never to plow the same depth twice in succession. In general, fall plowing should be from 7 to 9 or 10 inches, and spring plowing from 5 to 7 inches deep. There are special cases in which these rules do not apply, but their discussion would take us too far from the purpose of this paper.

We plow the soil in order to loosen up its texture and get air into it; also to turn under stubble, manure, etc., to make humus. Killing weeds is another object accomplished by plowing. After a soil has been thoroughly pulverized to great depths, so that there is no danger of turning up packed clay, the deeper the plowing the better the crops. But the cost also increases with depth, so that ordinarily it does not pay to plow more than about 10 inches deep.

Some crops prefer rather a loose seed bed. Millet is such a crop. Farmers sometimes plow a second time in order to sow millet on freshly plowed land. Other crops, such as wheat and alfalfa, prefer a fairly compact seed bed; hence, frequent harrowing and rolling after plowing is good practice before seeding to these crops. Nevertheless, it pays to plow the land for them, even if we have to compact it again before seeding. The plowing aerates the soil and helps to set plant food free.

Sandy soils are usually not injured by handling when wet; but the case is different with clay soils. A fair quality of brick can be made from any heavy clay soil by working it thoroughly when wet and then drying it in the sun. The effect produced by working clay soils wet is known as puddling. Irrigation ditches in the West are puddled by first flooding them to make them muddy and then driving bands of sheep along in this mud. This makes the bottom impervious to water and prevents loss from leakage. If a clay soil is plowed, or even harrowed, when too wet, it is more or less puddled. In this condition it becomes cloddy and impervious to air and water. Old roadways that have been thoroughly puddled from traffic in all kinds of weather may be distinguished in fields many years after they have been plowed up and put into cultivation.

The proper time to plow land is when it is just moist enough to break up mellow, neither wet enough to leave a slick surface where rubbed by the moldboard nor dry enough to break up in large clods; or, as the southern farmer puts it, when the soil has a good season in it. If continued rain follows wet plowing, little harm follows; but hot, dry winds would soon leave only a mass of unmanageable clods. In spring and midsummer plowing, particularly, it is of the utmost importance to run the harrow immediately after the plow. This prevents the formation of clods. In late fall plowing, the clods are no disadvantage, for they will be broken up by freezing and thawing during the winter.

One of the most serious results that follow shallow plowing, at least in hilly regions, is the washing away of the soil in torrential rains. In some sections, particularly in the southern portion of the Appalachian Mountain region, farmers have attempted to counteract this by means of terraces. Much of the farm land in the Carolinas, Georgia, and Alabama is nothing but a series of stair steps. When terraces are properly laid out they do prevent washing, but they are a very expensive means of accomplishing the end sought. They occupy land that ought to be in crops. They seed the land with weeds. When improperly constructed, and they usually are, they cause great ditches to be washed in the hillsides. Besides this they cut the land up into small, irregular patches and greatly increase the cost of tillage. There is a better way of preventing washing in nearly all cases.

In the first place, where land has been plowed only three or four inches deep for several years the subsoil becomes impervious to water and cannot absorb a heavy rainfall fast enough to prevent its flowing over the surface. But when the land is plowed gradually deeper until a good depth of loose soil is obtained, and particularly when an abundance of humus is supplied from grass roots and stubble, or from green crops turned under, or, better still, from barnyard manure, the soil becomes so porous that the heaviest rains cause little or no flowing of water on the surface. Striking illustrations of this fact are to be found on the farm of Mr. W. L. Williamson, of Jackson County, Ga., and on the farm of Rev. J. D. Detrich, described in the Yearbook of the Department of Agriculture for 1903 under the title "A Model Farm." In the Yearbook paper referred to, illustrations are shown of two fields lying side by side, both in rye. The pictures were taken within a few feet of each other. In one two large ditches had just been filled with dirt. In the other there was no tendency to wash. Mr. Williamson's farm is located in a region where terracing is very general. Since he abandoned cotton culture and began dairying he has plowed up all his terraces, and his land does not wash. He plows deep and manures heavily. But it is possible to accomplish similar results, even on a farm largely devoted to cotton, by deep plowing, and the use of green manures to supply humus.

We have seen that poverty in soil may be due to poor texture, unfavorable structure, lack of humus, deficiencies in the amount, form, or proportion of plant food, and to the presence of harmful mineral and organic compounds. With the exception of nitrogen, most soils, even those that are very poor, usually contain an abundant supply of plant food, though sometimes other elements are lacking or are present only in those forms that plants cannot use.

To increase fertility we must improve texture and add plant food and humus. Tillage may do much to improve texture, but tillage alone will not suffice. We must add humus. In doing so we add plant food, and make the soil more permeable to air and water.

There are three general methods of supplying humus to the soil. The first and best is the addition of stable manure. When properly managed it adds large quantities of both plant food and humus. But manure is not always available. When such is the case, the best thing to do is to make it available. Raise more forage, keep more stock, and make more manure. But this takes time and capital, so that other means are sometimes necessary. When stable manure is not to be had, we may plant crops for the purpose of turning them under, thus adding large quantities of humus at comparatively little cost. Plowing under green crops is called green manuring. Under certain conditions this is an excellent practice. Crops adapted to this purpose and the method of using them are discussed farther on.

A third method of adding humus is to grow crops like clover and timothy. These crops are usually left down for two years or more. During this time their roots thoroughly penetrate the soil. Old roots decay and new ones grow. When the sod is plowed up, more or less vegetable matter is turned under. This, with the mass of roots in the soil, adds no small amount to the supply of humus. Another advantage from the cultivation of clovers and alfalfa is found in the fact that they are deep-rooted plants, and when their roots decay they leave channels deep into the earth, thus aiding in the absorption of rains and letting in air to sweeten the soil.

Properly handled, stable manure is by all means the best remedy for poverty of the soil. Very few farmers handle manure so as to get even as much as half the possible value from it. There is probably no greater waste in the world than in connection with the handling of manure by the American farmer. Five-eighths of the plant food in manure is found in the liquid part of it. This is usually all lost. Not only is this the case, but the solids are piled beside the barn, frequently under the eaves, where rains wash away much of their value. Fermentation in these manure piles also sets free much of the nitrogen to escape into the air.

The writer has seen few farmers who had no apologies to make for their methods of handling manure. He has seen one, however, who believed he was getting every particle of value from the manure it is possible to get. The farm in question was a dairy farm, and the methods used are not applicable to all types of farms. The cows were kept in their stalls the year around. Every day in the year they had either silage or green stuff from the fields. They also had enough dry hay to keep the manure from being too washy, and what grain they needed. Behind each row of eight cows was a ditch 18 inches wide and 8 to 10 inches deep. This ditch was cleaned thoroughly every morning after milking hours. After the cleaning, a small quantity of wood ashes was sprinkled in the ditch to dry it; then a layer about 1½ inches deep of rotten sod or leaf mold was added. Next morning the contents of the ditch were lifted into a cart by means of forks, and the cart went immediately to the field where the manure was scattered. In exceptionally bad weather the ditch was sometimes left for two days. This farmer always had a place to put manure.

This method may not be applicable to all dairy farms, but it is the ideal to be followed as closely as circumstances will permit. If there is no sod on which to haul manure in wet weather, it is well to have a cemented pit under cover, in which to place the manure until it can be hauled to the field. When the ground is frozen in winter, manure can be spread on almost any field. Generally speaking, it should be spread on the field next to be plowed. The above method of handling manure gets both liquids and solids on the land. If any leaching occurs, let it be into the soil where the leachings will do the most good. Recent investigations indicate that when liquid manure is applied to the soil, the plant food in the manure is absorbed and held in the soil, and is not immediately washed out if not made use of by the plants.

The practice of plowing under green crops as manures is not very general, and we do not know as much as we should like to know of the value of this method. Some crops do not thrive when sown on land into which a green crop has recently been plowed. This is particularly true of those crops that like a solid seed bed, or which are sensitive to acids. When a heavy green crop is plowed under, it goes through a fermentation not unlike that which occurs in a barrel of kraut, resulting in the formation of a considerable amount of acid.

Alfalfa is particularly sensitive to acids, and it also requires a compact seed bed. It is unwise, therefore, to green-manure the land just before seeding to alfalfa. The cereals, particularly wheat and rye, do not do well after a green manure. On the other hand, potatoes and corn are not seriously injured by green manures. In fact potatoes are benefited by them, since the resulting acid condition of the soil prevents the development of potato scab.

Generally speaking, when it is desirable to plow in a green crop before fall-sown crops, it should be done a month or six weeks before planting time, and the soil should be harrowed frequently or otherwise compacted. A few good rains will wash out most of the acids and aid in compacting the soil. The acid may also be counteracted by adding lime.

THE MYSTERY OF MAN'S CAPACITY TO ANSWER A SIMPLE QUESTION.

THE exact course which those nervous impulses with which speech, throught, reasoning, deliberation, etc., are associated take in passing through the cerebral tissues is a mystery which students of psychic phenomena are trying to shed light upon. We do not know, for example, the exact course taken by the nervous impulses concerned in the production of a spoken answer to the simple spoken question: "Do you think it will rain to-day?" So says Dr. Byron Bramwell, lecturer on clinical medicine in the school of the Royal Colleges at Edinburgh and regarded as the highest living authority on aphasia and brain structure. In a recent lecture to the Royal College of Physicians, quoted in the London Lancet, he goes at length into the riddle of man's ability to answer the simplest question. We know, declares Dr. Bramwell, that the sound vibrations representing the spoken words, "Do you think it will rain to-day?" which enter through the ear cause nerve vibrations, which ultimately excite the function of the auditory speech center (see Fig. 1). We know that the spoken answer, whatever it may happen to be, is emitted by the vocal speech center. But we are not absolutely certain of the exact course which the nervous impulses take (*a*) in their passage from the ear to the auditory speech center; (*b*) in their passage from the vocal speech center to the lips, tongue, etc. We are still more ignorant of the exact course which the nervous impulses take in passing through the higher parts of the cerebral mechanisms—that is, between their point of entrance to the auditory speech center and their point of exit from the vocal speech center.

The question: "Do you think it will rain to-day?" after reaching, so to speak, and stimulating the auditory speech center, flows over and through connecting fibers to numerous associated centers and may excite a vast series of cerebral actions. A whole string of associated memories, ideas, and impulses may be called up in the mind, a number of voluntary actions may be produced and a number of new ingoing nervous impulses may be generated. Thus (to quote):

"The person who is questioned may look at the sky, at the barometer, at the weather report in his daily paper, he may note the direction and velocity of the wind, the temperature of the air and its degree of moisture, and then, after getting as much information as he can from the ouside, he may fall back upon and compare the information derived in this way with his own personal experience and with the information (knowledge) which he has acquired (stored up in the nerve cells of his cerebral cortex) from other persons or from books. Then, after due deliberation, a judgment or conclusion is formed, an answer is mentally determined upon, and, finally, that answer is put into concrete speech form (probably, so far as our present knowledge enables us to judge, in most persons in the auditory speech center) and is emitted through the vocal speech center. In order that this process of thought and reasoning may be carried out, a vast series of cerebral mechanisms and actions, throughout a large extent of the cerebral cortex (diagrammatically represented in Fig. 1 as a center—C.C.), must be brought into play. Consciousness, Intelligence, and the Will are actively engaged, the reasoning processes are called into play, after due deliberation a judgment is formed, and an answer is determined upon. All of these psychical phenomena are, it is needless to say, associated with corresponding physical changes, with definite changes of a physical kind in nerve (cell and fiber) mechanisms in the different parts of the cerebral tissue which are engaged and brought into action. Finally, under the influence of the will, of a *fiat* of the

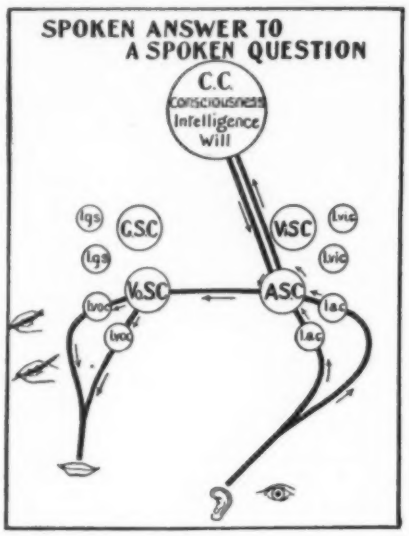


FIG. 1.

Diagrammatic representation of the course which the nervous impulses concerned in the production of a spoken answer to a spoken question take. A.S.C., auditory speech center; l.a.c. and l.a.c., lower auditory centers on the left and right sides of the brain respectively. Vo.S.C., vocal speech center. l.vo.c. and l.vo.c, lower vocal centers in the left and right sides of the brain respectively. C.C., hypothetical center representing the seat of Consciousness, Intelligence, and the Will. The nervous impulses concerned in a spoken answer to a spoken question enter, so to speak, through the ear and pass to the auditory speech center (A.S.C.), through the lower auditory centers (l.a.c. and l.a.c.); from the auditory speech center they pass to the ideational centers in different parts of the cerebral cortex, in the diagram hypothetically represented as a special center (C.C.) the seat of Consciousness, Intelligence, and the Will. After a judgment has been formed and the answer has been determined upon, the nervous impulse passes from the higher cerebral centers (C.C.) to the auditory speech center, where it is put into concrete speech form; from the auditory speech center it passes to the vocal speech center (Vo.S.C.) and thence, through the lower vocal centers (l.vo.c. and l.vo.c.), to the larynx, tongue, lips, etc., where it is emitted as spoken sounds.

will, as it is termed, a motor discharge, which is represented externally by the spoken answer to the question, is emitted. Even the, comparatively speaking, elementary point—the exact course which the nervous impulses take in the final stage of the process after the answer has been mentally determined upon—is as yet uncertain. We do not know, after a judgment has been formed and an answer has been mentally determined upon, whether the nervous impulses which are necessary for the production of the discharge of the vocal speech center (the production of the spoken answer to the question) must pass (*a*) through the auditory speech center, in order to act upon the vocal speech center (as is represented in Fig. 1); or (*b*) whether the higher parts of the cerebral mechanism (C.C.) in which the judgment has been formed and the answer determined upon can play directly upon

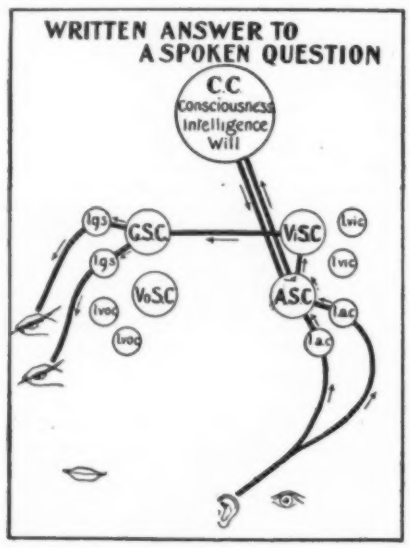


FIG. 2.

Diagrammatic representation of the course which the nervous impulses concerned in the production of a written answer to a spoken question take. A.S.C., auditory speech center; l.a.c. and l.a.c., lower auditory centers, Vl.S.C., visual speech center. G.S.C., graphic speech center; l.g.s. and l.g.s., lower graphic centers on the left and right sides of the brain respectively. The spoken question passes in by the ear to the auditory speech center (A.S.C.), ? through the lower auditory centers (l.a.c. and l.a.c.); from the auditory speech center, nervous impulses pass to the higher "ideational" centers, diagrammatically represented as the center C.C. After the answer has been determined upon the nervous impulse passes from C.C. to the auditory speech center (A.S.C.), where it is put into concrete speech form; from the auditory speech center (A.S.C.) it passes to the visual speech center (Vl.S.C.), where it is translated into visual speech symbols; from the visual speech center (Vl.S.C.) it passes to the graphic speech center (G.S.C.), thence it is emitted through the lower graphic centers (l.g.s. and l.g.s.) either to the right or left hand.

the vocal speech center (Vo.S.C.) (i. e., without acting through the auditory speech center) . . . and, if so, (*c*) what is the course which such nervous impulses take."

It would appear, so far as our present knowledge and information enable us to judge, that in most normal individuals, at all events, the action is through the auditory speech center (Fig. 1). This would appear to be the case so far as the names of objects and many actions and attributes are concerned. Whether the same statement applies to the other parts of speech is more doubtful in Dr. Bramwell's opinion. Probably, he says, the auditory speech center is first stimulated, and then, under stimulation from the auditory speech center, the vocal speech center is put into action.

Again, the answer to a spoken question may be emitted or discharged by the graphic speech center. In this case it would appear that after the answer has been mentally determined upon, it is, as in the former case, first put into concrete speech form in the auditory speech center, from which the nervous impulses pass to the visual speech center (Fig. 2), where they are translated into visual speech symbols; and then from the visual speech center they pass on to and out by the graphic center. But there is reason to suppose that in certain circumstances (probably in some normal individuals and certainly in some cases of disease) the "ideational" centers (C.C.) can, as it were, play directly upon the visual speech center (Vl. S. C.) In some cases, for example, in which the auditory speech center is inactive or destroyed the patient is still able to write spontaneously.

The same uncertainty applies to the course of the nervous impulses which are concerned in the production of a spoken and written answer to a written question. It is not improbable that a solution of this problem would carry with it an explanation of the vagaries of human testimony conveyed by word of mouth and in writing.

THE FLYING AND SOARING OF BIRDS EXPLAINED BY WELL-KNOWN MECHANICAL PRINCIPLES.*

By H. LAV. TWINING.

THE flying and soaring of birds can be explained upon well-known mechanical principles, and it is surprising that these feats of winged creatures have remained so much of a mystery up to the present time. A great many complicated and far-fetched theories have been proposed to account for the apparent ease with which birds sustain themselves in such a thin fluid as the air.

Many have supposed that some unknown and strange property of gases, or some deeply hidden structure in the bird itself, lies at the basis of its seemingly strange power. There can be no question but that the structure of the machine has an important bearing upon this problem, but that structure is neither hidden nor complicated. No new property of gas need be invoked in its explanation, either. It is not the purpose here to review what has been accomplished by others up to the present time, but to present the results of some simple experiments and observations made during the past fifteen years, in the hope that they may prove of some value in the solution of the problem of aerial navigation.

The bird is a living machine, immersed in an atmosphere of mobile and perfectly elastic matter, from which it obtains support by the expenditure of energy on the part of itself, whether flying or soaring.

The whole question resolves itself into a study of the machine, the atmosphere, and their relation to one another. To deal with the subject fully requires a book, and here it is possible only to mention those principles and structures which are fundamental.

THE MACHINE.

This bird or machine has weight very many times greater than the air it displaces. This is fundamental. The animal is composed of a body, in which the weight is concentrated, and the wings, which are very light. This lightness of wing is fundamental, and it will be discussed later. The wings are attached by their anterior edges to the body, above and in front of its center of gravity. This is fundamental, and its significance seems to have escaped observers up to the present time.

In Fig. 1, let *A B C D* be the body of a bird with the center of gravity at *N*. Let *E F G H* be a wing with its center of surface at *O*. Let *M F* be the anterior edge of the wing attached to the anterior and dorsal part of the body at *M*. This machine pitches backward and downward, if supported by placing the fingers along the edge, *M F*, of each wing. If the fingers be placed along the edge, *H G*, of each wing, the body pitches forward, but if the fingers of each hand be placed at *O* of each wing, the body balances forward and rear. The truth of the above construction and observations can be easily verified by examining a dead bird. If this machine be suspended in the air, it begins to fall at once, and becomes a lever of the first class.

O L is the power arm, *M L* the fulcrum, and *M K* the weight arm. As the machine falls, the weight of the body, *A B C D*, centered at *N*, tends to revolve downward and around *M L* as an axis, because of the fact that the weight is supported at the point, *M*, above and in front of the center of gravity. The resistance of the air upon the wing, centered at *O*, tends to rotate the weight upward and around *M L* as an axis. If the weight of the body and the dimensions of the wing

* This article was specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT. Mr. Twining is a teacher of physics in the Los Angeles Polytechnic High School.

are rightly proportioned, these two tendencies are equal; and consequently the machine is in equilibrium. The weight of the body is thus balanced against the upward thrust of the air on the wings around *M L* as a fulcrum. Under these conditions the machine cannot fall directly to the ground, but it glides down a very steep inclined plane, constantly maintaining an even keel. It is balanced on the right and left by the equal resistances offered by the wings. It can pitch neither

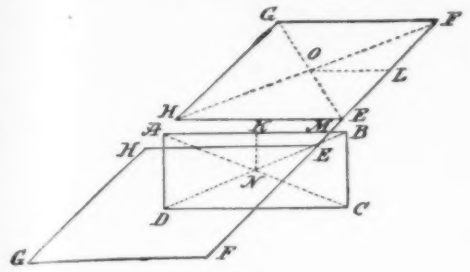


FIG. 1.

forward nor backward, nor to the right or left. If a sliding weight be placed upon the line *C D*, directly under *N*, in a model constructed upon the above principles, the conditions of equilibrium are maintained. If the weight be slipped forward toward *C*, the machine immediately pitches forward. If the weight be slipped backward toward *D*, the machine pitches backward.

All birds are constructed upon these principles, and when the wings are kept extended by the muscular effort of the bird, it can neither plunge forward or backward, nor to the right or left. It is thus in equilibrium as long as the wings are extended. The animal has power to displace its center of gravity by lowering or raising its body around *M L* as an axis. If the body be lowered as in alighting, the under surface of the wings are brought strongly against the air in front and its motion is checked. If lowered slightly, the bird glides forward and upward. If the body be raised the system is less stable, and hence it pitches forward and downward. By the use of the wings on either side and by its control over its center

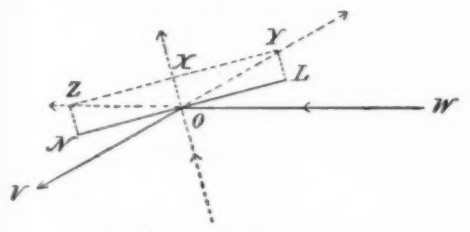


FIG. 2.

of gravity, it is able to go in any direction and maintain its equilibrium. The tail acts as a rudder, but as it is of minor importance, it need not be considered here.

In Fig. 2, let *N O L* be a cross section through the wing, *E F G H*, along the line *O L* of Fig. 1. Let a wind blow from the direction of *W* upon the line *N L*. (Keep Fig. 1 in mind throughout the entire discussion.) Since *N L* is a lever with the fulcrum at *L*, and since the power of the impinging wind acts all along this lever, the sum of the effects of all the impacts on the lever is at *O*, the center of the line, *N L*. This impact at *O* is resolved into two forces, one normal to *L N*, and one parallel to *L N*. Prolong *W O* and complete the parallelogram of forces *O X Z N*.

O X, the resultant normal to *L N*, tends to rotate *L N* upward around *L* as a center and to lift the ma-

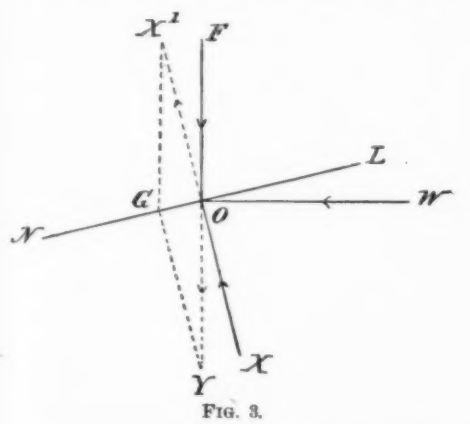


FIG. 3.

chine perpendicularly. The resultant, *O N*, parallel to *L N*, tends to drive the machine backward in the direction *L N*. The resistance to motion in the direction *L N* is great, owing to the construction of the wing. The resistance to motion in the direction *N L*, however, is very small, for the same reason; hence the action in the direction *O N* is reversed and, as a reaction, drives the machine forward in the direction *N L*, along the line of least resistance, which is forward in the plane of the wing. The reflection of the air at *O* from the wing takes the direction *O V*, the angle of incidence and reflection being equal, and reacts on the wing in the direction *V O*. This reaction is resolved into two forces, one normal to *N L* and one parallel to *N L*.

Prolong *V O* and complete the parallelogram of forces *O L Y X*. The component *O X* tends to rotate the wing upward around *L* as a center and to lift the machine perpendicularly. The component *O L* drives the machine forward along the line *N L*, which is the line of least resistance in the plane of the wing.

Furthermore, the rebounding particles of air are not rebounding into empty space, but into a space filled with a stream of particles with which they come into collision. On account of this resistance to their rebound the reacting particles deliver a stronger blow to the wing than they do on impact. Thus the reaction is stronger than the impact.

On account of the shape of the wing, and on account of the fact that the feathers overlap each other from front to rear, the resistance to motion forward is very small compared to the resistance encountered to motion backward, and hence all components tending to force the machine backward encounter this resistance, which reacts and forces the machine in the opposite direction. The resistance to motion in a direction normal to the surface of the wing is very great, but motion parallel to the plane of the wing is accomplished with slight resistance, especially forward. This can be easily demonstrated by mounting and main-

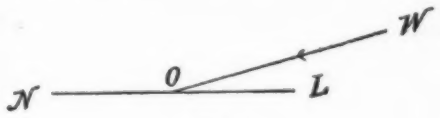


FIG. 4.

taining a wing in an open position for purposes of experiment.

A fan, however, will illustrate this point. Everybody is familiar with the surprising ease with which a fan can be moved in a direction parallel to its surface, and with the great resistance developed if it be moved in a direction normal to its surface. The swifter the motion, the better the result in either case.

In Fig. 3, let *O X* represent the normal resultant due to an impact *W O*, and let *F O* represent the resistance of the air above the machine to rotation and to perpendicular lift, exerted by this reaction. Complete the parallelogram of forces *O X G Y*. The resultant of the components *F O* and *O X* is *O G* in the direction *O N*. But the resistance to motion in the direction *O N* is great, and this resistance reacts and drives the machine in the direction *O L* along the line of least resistance in the plane of the wing.

If *L*, the front edge of the wing, be lower than *N*, the rear edge of the wing, and the moving air strike its upper surface as in Fig. 4, the effect is the same, except that the wing is rotated downward around *L* as a center. The component parallel to the wing acts as just explained. The component normal to the wing rotates it downward around *L* as a center. This component is compounded with the resistance of the air to this rotation and to perpendicular motion downward

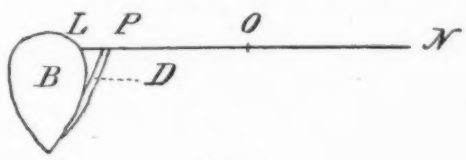


FIG. 5.

just as in Fig. 3. Thus all forces acting on the wing, no matter from what direction they may come, resolve themselves into these two components, and these two components have a resultant forward in the plane of the wing, along the line of least resistance. The machine is thus held firmly between two planes of resistance, between which it glides smoothly forward.

If the air be still and if the wings be vibrated, the action and the reactions are the same and can be explained as above. But the air is never still around a vibrating wing, as will soon be shown. If the wing strike the air normal to its surface, either in the up stroke or the down stroke, the reaction rotates the wing around its front edge as an axis, and the result is as explained in Fig. 3. If the wing strike the air at any other angle, the result is as explained in Fig. 2.

If the air be moving and the wing be vibrated, the results are the same but the reactions are stronger. The upward stroke drives the bird forward in the plane of the wing just as surely as the downward stroke does. This fact seems to have escaped detection, and the effect of the up stroke of the wing has been entirely misinterpreted. This will be discussed fully further on. The length of the wing and the attachment of the muscles that operate it have a bearing on this problem.

In Fig. 5, let *B* be the body of a bird. Let *L N* represent the wing, attached to the body at *L*. Let *D* represent the depressor muscle. Let *O* midway between *N* and *L* represent the sum of all the resistances reacting on the wing, as it rotates around *L* as a fulcrum in its vibrations. *L O* is then a lever of the third class. The power is applied at *P*. The fulcrum is at *L*, and the sum of all the resistance is at *O*.

In the turkey buzzard, weighing four pounds, the wing is eighteen inches long. The depressor muscle is attached to a flat process at the top of the humerus, one inch from the shoulder joint. The muscle itself, which is located on the breast, is very large. The elevator muscle is located on the breast underneath the depressor muscle. It is very much smaller than the depressor muscle. It sends a ligament through a hole in the shoulder over the end of the humerus, and attaches to it at less than an inch from the shoulder joint.

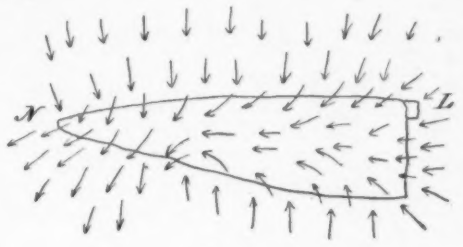


FIG. 6.

Since the turkey buzzard weighs about four pounds, each wing must develop a resistance of two pounds in order to sustain this weight. If Fig. 5 represents a turkey buzzard, the reaction at *O* is then two pounds. Let *P* represent the power necessary to be exerted at *P* in the figure, in order to balance a resistance of 2 pounds at *O*. Then *P L* is the power distance, and *O L* is the weight distance. In the equation $P \times P L = O \times O L$, substitute the numerical values found in the turkey buzzard. Then $P \times 1 = 2 \times 9$ and $P = 18$. Hence the depressor muscle must develop a pull of 18 pounds per wing, or 36 pounds in all to sustain 4 pounds in the air. Thus the bird weighing four pounds with the wings as described must make a muscular effort of thirty-six pounds in order to maintain its wings against a reaction of two pounds to the wing, which is necessary to maintain its position in the air. If this muscular effort be relaxed for an instant, the wings collapse and the bird falls to the ground. It must be borne in mind that but one factor is being considered at a time here. There are other factors that will be considered later, which show that it is not necessary to exert a constant and steady pull of this character.

In the light of what has been developed, the soaring

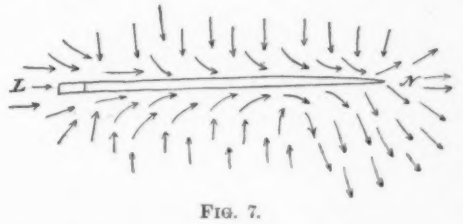


FIG. 7.

of a bird can be easily explained. The assertion often made that a bird soars without effort or expenditure of energy on its part is of course untenable. The turkey buzzard, in order to maintain its four pounds of weight in the air while soaring (omitting the factor due to its motion), must maintain a constant pull of thirty-six pounds in order to hold its wings against the resistance of the blowing wind. The moving wind impinging upon the slightly inclined surfaces of the wings acts as explained in Figs. 1, 2, 3, and 4. In order to obtain this reaction, the wings must be maintained against the developed reaction, and this requires the expenditure of energy as shown above.

This living, soaring machine is then constantly driven forward along the line of least resistance in the plane of the wing, even into the very teeth of the howling gale. This magnificent sailing machine, in the gentle breeze or in the fiercest gale, rises or falls, goes to the right or left, or circles in great spirals, up or down, with perfect freedom, constantly sailing, without the flap of a wing.

No matter what quarter the wind comes from, unless it be directly from the right or left of the bird, it can

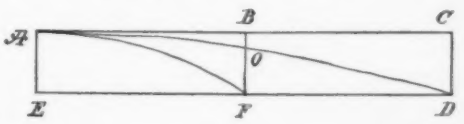


FIG. 8.

have but one resultant upon the machine, and this is forward in the plane of the wing. Theoretically, the wings must vibrate slightly around the front edge of the wing as an axis under the force of the wind, being rotated upward from below and downward from above alternately as the wind strikes the under and then the upper surface, but this motion is so slight, if it exists, as to be imperceptible to the eye.

THE SHAPE OF THE WING.

The shape of the wing has a very important bearing upon its action on the air. In order to determine how the wing acts on the air, a silk cloth two feet wide and three feet long was suspended by one end from a support, the other end being free. A turkey buzzard's wing was mounted upon a handle and fixed in an extended form. By holding the wing in the hand at

the shoulder joint, it was vibrated normal to its surface around the hand as a center, imitating as far as possible the natural movement of the wing in normal flight. Under these conditions the vibrating wing was brought near to the suspended cloth with the following results:

When the front edge of the vibrating wing was brought near the cloth, the cloth stuck to its edge as though glued there. If the vibrating wing was held at a little distance from the cloth, the cloth was seemingly attracted by the wing, and it stuck to it as before. This result was obtained all along the front of the wing, at the end of the wing near the hand, and along the rear edge of the wing for two-thirds of the distance toward the tip. When the remaining one-third of the rear edge of the vibrating wing was presented to the cloth, it was blown violently away from the wing. Let Fig. 6 represent the under side of a wing, and *N L* its front edge. The arrows indicate the direction of the air currents in a plane parallel to the plane of the wing, as shown by the action of the silk cloth and bits of paper strewn upon a table top over which the wing was vibrated.

When either the convex or the concave surface of the wing was brought near to the silk cloth, it was apparently attracted by the wing, and stuck to it as though glued there. In Fig. 7, let *L N* represent the front edge of a wing with the shoulder joint at *L*. The arrows indicate the direction of the currents of air in a plane normal to the surface of the wing. By these two experiments it was shown that the air comes in toward a vibrating wing from above, from below, from the whole front, and from the rear for two-thirds of its length. This air is gathered into two streams, one above the wing and one below the wing, and discharged at the rear tip of the wing for one-third of its distance. At this place the air is driven violently away from the wing, slightly upward and outward but largely backward, or backward and downward, forming a large cone of moving air with the apex at the one-third of the rear edge of the wing.

The bird thus literally creates a breeze toward itself from all directions but one. This is due to the shape of the wing, which in its vibrations forces the air under it toward the tip. Air must come in from all quarters toward this area of low pressure thus created. When the wing is depressed, it encounters the column of air which is moving upward from below and forces it along its length toward its tip to the rear. The greatest area of low pressure is at the tip, because the greatest motion exists there. When the wing is depressed the air above follows it down, and when the wing is elevated it meets this column of descending air, which flows toward the area of low pressure at the tip of the wing. The air coming from the front and rear of the wing is met by it and used in the same manner.

From these currents of air and from their reaction upon the vibrating wing, the animal derives its support as explained in Figs. 1, 2, 3, and 4. The upstroke of the wing drives the bird forward in the plane of the wing just as surely as the downstroke does, as explained in Figs. 3 and 4, but the burden of supporting the wing against the reaction of the upstroke is thrown largely upon the depressor muscle, in the following manner: when the upstroke is made the wing rotates downward around its front edge as an axis, and the lower surface of the wing meets the oncoming air, due to three causes, viz., the blowing wind, the vibrating wing, and the movement of the bird forward. This reacts on the under surface of the wing as already explained, and the depressor muscle must take up the strain. It is of course evident that the upper surface of the wing, on account of its convexity, does not develop as much resistance as the under surface of the wing, but all the resistance that is developed is turned to account.

In the upward and downward stroke these two muscles never let go, but merely give way to one another. The wing is thus held firmly between two pulls. As the bird moves through the air in flying, the head and the abdomen bob up and down alternately around the front edge of the wing as an axis. This motion cannot be easily seen in small birds; but in birds the size of sea gulls it can be easily seen, although it is difficult to tell what relation the bobbing bears to the wing stroke. In the dove or pigeon it can be seen quite distinctly as it is on the point of alighting on the ground. In the pelican, however, the relation can be distinctly made out as it flies through the air. In the winter the pelicans congregate at San Pedro, Cal. I have watched these large birds rise with the greatest of ease directly from the water. As they rise the motion of the abdomen is very marked. By counting up, down, up, down, etc., as the wing is raised or lowered, and by watching the abdomen at the same time, I could easily see the abdomen rise as the down stroke of the wing was made, and fall as the up stroke of the wing was made. The motion was rotary around the front of the wing, and not a lifting or depressing of the bird bodily. The head thus bobs up when the upstroke of the wing is made, and bobs down when the downstroke is made. The motion of the bird forward is constant without check from the upstroke, as was erroneously inferred by a French investigator, E. J. Marey, in a book entitled "Animal Mechanism."

In Chapter IV., Fig. 115, of the above book is found the curve produced by tracings made by pneumatic drums placed upon the flying bird. The tympanum of the drum is loaded with weights. This curve seems to indicate that the upstroke of the bird's wing retards its onward course. This conclusion was due to a misapprehension as to the actual movement of the bird's body in flight. The drum was placed in a vertical position between the shoulders of the bird, and hence on the upstroke of the wing the drum was carried backward by the downward rotation of the body around the front edge of the wing. This backward motion of the drum gave a retrograde curve in the tracing, and it was naturally inferred from this that the upstroke caused a retarding of the onward movement of the bird. Not being aware of this downward rotation, the only inference that could be drawn was the one made.

The front edge of the pelican's wings, when the neck is outstretched, is in line with its center of gravity. In order to fly, the pelican carries its heavy head away back upon its body, resting its long beak upon its reflexed neck, which lies backward along the dorsal surface of the body. When it wishes to dart downward into the water in order to seize its prey, it merely stretches out its neck and throws forward its heavy head and beak. This brings the center of gravity forward to the front of the wing, and the bird pitches forward and rushes headlong into the water. When the head is resting back on the body, the center of gravity is back and below the attachment of the wings.

THE ATMOSPHERE.

The perfect elasticity of the air, its mobility, its density, its inertia, and its weight, are factors in the problem of flight. The air flows in from all directions toward a region of low pressure, because of its weight as a whole, and because the pressures due to this weight are transmitted in all directions. By the vibration of its wings the bird creates a region of low pressure, and the air rushes in toward that region from all directions but one. This pressure plays an important part in flight upon the principles explained in Figs. 1, 2, 3, and 4.

The inertia of the air and of the heavy bird also cut a figure. As the animal rises from the ground, flapping its wings, it drives a great current of air outward toward the tips and to the rear, but it makes little or no headway itself. Its inertia being so much greater than the inertia of air with which it has to deal, it stands still and drives the air. It is like the great steamship as it starts from the wharf. At first its propellers drive a great stream of water away from it toward the rear, but the ship itself scarcely moves. Little by little it gains headway, and then the water in its wake is churned and agitated, but it is not driven bodily backward as it was at first. The inertia of rest is now changed to inertia of motion, and since the inertia of motion is in the direction of the reaction, the water stands still and the ship moves.

So it is with the turkey buzzard as it rises from the ground. At first the air is driven in a great stream backward and downward, as is demonstrated by the great scattering of leaves and dirt beneath and behind it. As it slowly gains headway this stream of air is less and less, as can be seen when the bird flies along the ground when under full swing. The inertia of the bird, as it starts, stands against the reacting air and drives it from it, but when under way, the bird is driven and the air stands more strongly in its reaction, giving motion to the bird instead of receiving motion itself.

The wing must be light, the lighter the better. The bird can be as heavy as you please within the limits prescribed by the strength of material required in the wing necessary to support the weight. If a heavy plate be vibrated or struck downward against the air, no resistance to its motion is perceptibly developed because its great momentum drives the air bodily out of the way. The inertia of the air is insufficient to make a stand against the great inertia of motion in the plate. If a fan of the same area and shape of the plate be vibrated or struck downward, great resistance to its motion is developed, because the momentum of the fan is small owing to its small mass. Thus the inertia of the fan and the inertia of the air are more nearly equal, and the air is able to stand effectively against the fan.

The flying bird must be heavy. If the mass of the bird and the numerical expression of the striking force of the moving air be equal, the bird is driven bodily backward by the impact of the air upon its body; but if the numerical expression of its mass be much greater than the striking force of the air at the instant of impact, the inertia of the mass enables it to stand against the impact, and the reactions upon the wings soon cause the animal to move rapidly in the very teeth of the impact.

The length, the width, and the rapidity of vibration of the wing are all functions of one another. If the weight of the bird be a constant, the above factors are variables. If the area of the wing be great, it must vibrate slowly; but if it be small, the wing must vibrate swiftly. If the wing be long, it must be narrow, other things remaining equal. If the wing be long and narrow, it must vibrate slowly. If it be short and narrow, it must vibrate very rapidly. The narrower the wing and the longer it is, the more powerful it becomes for sailing and effective flight. But in this case the bird must have powerful muscles. Hence there is great latitude for the exercise of variety in the shape, size, and velocity of vibration of the wings.

It is at the tip of the wing where the most effective work is done. The farther the tip is from the body, the more effective the reaction, and the greater must be the muscular power of the bird in order to maintain the wing against the reaction. The truth of these observations is derivable from the demonstrations here given.

MOTION.

When a stone is thrown through the air, it stays up by virtue of the motion imparted to it, and it pursues a path which is a resultant between that motion, the pull of gravity, and the resistance of the air. The stone does not rest its weight upon the air in its flight; in fact, it would stay up longer if the air were absent.

In the same way a bird once under way does not rest its weight upon the air. By virtue of its motion it is relieved of constantly exerting enough force to maintain itself in the air. If it were to close its wings, it would still go forward for a short distance without falling appreciably. It is only necessary, then, to strike the air often enough to keep up this motion. The bird can be regarded in the light of a falling body.

In Fig. 8, let *A* be a bird moving in the direction of *C*. Suppose it travel the distance *A B* in a given time. Let *A E* represent the pull of gravity in value and direction in the given time, *A E* being perpendicular to *A B*. Complete the parallelogram of forces, *A B E F*, and describe the parabolic curve, *A F*. At the end of the given time, the bird will be at *F* instead of at *B*, having traversed the curve, *A F*, which is the resultant of the two forces, *A B* and *A E*. Suppose the bird travel twice the distance, *A B*, in the given time. Prolong *A B* to *C*, making *B C* equal to *A B*. The bird falls only the same distance as before. Complete the parallelogram of forces, *A C D E*, and describe the parabolic curve, *A O D*. This curve is the resultant of the two forces, *A C* and *A E*. Hence in traveling *A B* at twice the speed, the bird falls only through the distance, *B O*, which is less than one-half of *B F* through which it fell before in traveling the distance, *A B*. Let the speed of the bird increase indefinitely. As the speed increases, *A O* approaches *A B* as a limit, and *B O*, the downward component due to the pull of gravity, becomes less and less, approaching *B* as a limit, where at an infinite speed it becomes zero. The weight of a bird moving at an infinite speed would then be zero. From this demonstration it is seen that the swifter a bird moves, the less the component due to gravity becomes, and hence the less the bird weighs. Its mass of course remains the same all of the time.

The flying bird needs, then, only to strike the air often enough to make up for its fall in a given time and for its loss of motion due to the friction of the air. At all other times it does not rest upon the air at all, any more than a projected stone does.

The swifter the motion, within certain limits set by the friction of the air on the body, the less the energy necessary in a given time to keep up that motion.

THE CHEMISTRY OF PLANT ASSIMILATION.

THE atmosphere is composed of about 79 per cent of nitrogen and 21 per cent of oxygen when we consider their volumes, but 77 per cent of nitrogen and 23 per cent of oxygen when we consider their relative weights. With these gases there are mixed small quantities of carbonic-acid gas, ammonia, hydrocarbons, and other impurities. With this "dry atmosphere" there is intermixed a very variable quantity of aqueous vapor or moisture, which in extreme cases may amount to as much as 5 per cent, by weight, of the dry air. These are the elements that are to be compounded by sunshine and heat in the laboratory of vegetation.

By respiration the leaves of plants, when in the dark, absorb oxygen from the air and set free carbonic-acid gas.

By assimilation, as shown by Garreau, these same leaves in the sunshine absorb carbonic-acid gas from the air and set free oxygen retaining the carbon in new compounds. Assimilation is a process of greater intensity than respiration. Respiration is a process analogous in its results to that occurring within every animal organism, but assimilation is a process peculiar to the plant life.

By transpiration the leaves rid themselves of the superfluous water that, as sap, has served its purpose in the process of assimilation by bringing nourishment from the soil and delivering it up to the cells of the plant; a small portion of the nourishment and of the water may have been absorbed by the cells in the trunk of the tree, the stem of the vine, or the stalk of the grain and grass, but the majority of the water is removed by transpiration at the surface of the leaves in order to make room for fresh supplies of sap. Some water always remains in the cells of the seeds and grains until they are dried after maturity, but a well-dried crop contains relatively little water. This transpiration is stimulated by, and almost entirely depends upon, the action of sunshine on the leaves; it precedes evaporation.

Evaporation is not transpiration; the former takes place from the surface of water existing either in the moist earth or in films on leaf surface or in larger masses, while transpiration takes place through the cell wall and is a process of dialysis, an endosmosis and exosmosis by which the cell takes in the sap, retains what it needs, and then gets rid of the water and the dissolved substances which it does not need. Thus the cell wall thickens and enlarges and the contents of the cell increase. The sap enters the cell from that side of the cell which is turned toward the interior of the plant or adjacent cells, and the rejected water penetrates the cell wall on that side of the cell which is exposed to the open air, and especially on that side exposed to the sunshine; having reached the outer surface of the cell wall on this side of the cell it is then evaporated. This endosmosis by which the sap enters the cell on one side, and the exosmosis by which it

leaves the cell on the opposite side, constitute the fundamental mechanics of all vital activities; the chemistry of animal and vegetable life differs from the ordinary chemistry of the laboratory in that the former studies the behavior of the cell wall toward the molecule, while the latter studies the behavior of the molecule toward the molecule. An interesting contribution to the development of this idea of the chemistry of the action of the cell is contained in two papers by Miss Abbott (now Mrs. Michael, of Philadelphia), published in 1887 in the Journal of the Franklin Institute; from the second paper I take the following extract:

The botanical classifications based upon morphology are so frequently unsatisfactory that efforts in some directions have been made to introduce other methods.

There has been comparatively little study of the chemical principles of plants from a purely botanical view. It promises to become a new field of research.

The Leguminosæ are conspicuous as furnishing us with important dyes, e. g., indigo, logwood, catechin. The former is obtained principally from different species of the genus *Indigofera*, and logwood from the *Hæmatoxylon campechianum*, but catechin from the *Acacia catechu*.

The discovery of hæmatoxylon in the *Saraca indica* illustrates very well how this plant, in its chemical as well as botanical character, is related to the *Hæmatoxylon campechianum;* also, I found a substance like catechin in the *Saraca*. This compound is found in the Acacias, to which class *Saraca* is related by its chemical position as well as botanically. Saponin is found in both of these plants, as well as in many other plants of the Leguminosæ. The Leguminosæ come under the middle plane of multiplicity of floral elements, and the presence of saponin in these plants was to be expected. . . .

From many of the facts above stated, it may be inferred that the chemical compounds of plants do not occur at random. Each stage of growth and development has its own particular chemistry.—Cleveland Abbe in Bulletin No. 30 of the U. S. Department of Agriculture.

CONTEMPORARY ELECTRICAL SCIENCE.*

ACTINO-ELECTRIC PHENOMENA.—H. Dufour has examined a number of different bodies with a view to discovering new photo-electric effects. They included amalgamated zinc, known for its great sensitiveness to ultra-violet light, an Auer incandescent mantle, and wire netting, either bare or blackened, so as to determine the effect of adhesive layers of gas. The ultra-violet light was derived from an arc lamp, while infra-red rays were obtained from a Nernst lamp, an electric furnace, or a red-hot cannon ball. The author endeavored to discriminate between the "corpuscular" rays emitted by the body under the influence of illumination and the impact of ions proceeding from the radiating body. The latter is specially active in the case of the electric furnace or cannon ball when shining with a very faint light. It has the effect of retarding the discharge provoked by ultra-violet light or similar agents employed at the same time, just as it extinguishes the luminescence of a body. When the furnace gets more luminous it begins to acquire an action of its own, but only on negatively-charged bodies. This discharging action rapidly increases up to a bright red heat.—H. Dufour, Physikalische Zeitschrift, December 1, 1905.

SPARK DISCHARGE IN GASES.—The sparking length in gases and the potential necessity to produce a discharge are known to depend upon the velocities of the gaseous ions, as well as the molecular weight of the gas. The ionic velocity often becomes the determining factor. W. Voege thus quotes an instance in which the conductivity of air for the spark discharge becomes less than the conductivity of carbonic acid. This happens when the spark length exceeds 10 centimeters. Oxygen appears to discourage the discharge in every case, but the author cannot say whether this is due to the formation of ozone. The discharges in the various gases may be distinguished by the sound and the shape of the spark. In air, the negative electrode is a bright point and the anode a brush. The spark is white and loud, and has a zig-zag shape. The portion nearest the cathode is bright. This is not the case in oxygen. In carbonic acid and hydrogen the sparks are straight and nearly silent. The spark in hydrogen is red and in carbonic acid blue, except at higher current intensities, when the oxygen liberated makes it violet. Hydrogen or carbonic acid surrounding the cathode encourages the discharge, just as positive ions do. This is consistent with the positive charge of the hydrogen atoms in electrolysis. Chlorine, on the other hand, hinders the discharge, since each atom has a tendency to take up an additional electron and become a negative ion.—W. Voege, Annalen der Physik, No. 13, 1905.

A NEW ELECTRIC VALVE.—A. Wehnelt has utilized the emissive properties of metallic oxides for the construction of a new valve tube. He showed last year that metallic oxides, especially those of calcium, strontium, and barium, when incandescent, emit numerous negative ions. When they are spread over a cathode they neutralize the positive ions accumulating there during the discharge, and therefore reduce the cathode fall to vanishing point. The cathode is made of some refractory metal and heated by a special current. The anode fall is some 20 volts. The tube is highly exhausted. When the heated oxide is made the cathode, the current passes easily, but on reversing the current it does not pass with less than several thousand volts. The limit of action is reached when the current density becomes so great that at the temperature of incandescence the negative ions no longer suffice to neutralize the positive ions accumulating from the gas. This limiting current density is 2 or 3 amperes per square centimeter. An alternating current is converted into an intermittent direct current, as in the case of other valves. The author claims a high efficiency, but reserves his figures. Besides the use for charging accumulators and working lamps from drehstrom circuits, he also uses the valve for wireless telegraphy, sending both components of the wave in the same direction through the coils of a differential galvanometer. —A. Wehnelt, Sitzungsberichte, Phys. Med. Soc., Erlangen, 37, 1905.

RADIATION FROM METALS AND CRYSTALS.—F. Sanford has pursued his researches on the ultra-violet radiation from metals when joined to the cathode of the secondary of an induction coil or placed in the field of an air condenser, the plates of which are joined to the terminals of an induction coil. The wave-length of the radiation was measured by means of a Rowland grating, this and the photographic plate being inclosed in a dark box placed between the glass plates upon which the tinfoil condenser sheets were pasted. The rays passed through a slit in a vulcanite screen and through the grating and fell upon the sensitive plate. The wave-length was determined in the case of 15 metals, and was found to range from 329 $\mu\mu$ in the case of tinfoil to 380 $\mu\mu$ in the cases of zinc, manganese, lead, and platinum. A number of crystals of various salts were tried as radiators by sticking a crystal with glue on a piece of cardboard which was placed upright in a dark box in front of the ebonite slit. Silver nitrate and potassic ferrocyanide showed a wave-length of 334 $\mu\mu$, and potassic bromide 370. In the case of radiation from crystals, even more than from metals, it was found that sharp points or edges were the principal sources of the radiation. Photographs of crystals made by means of their own radiations and by the use of a quartz lens showed only a number of point or line sources of the radiation.—F. Sanford, Physical Review, November, 1905.

RESISTANCE OF SELENIUM.—To measure the resistance of selenium it is usually fused between two metallic plates. By rapid cooling a vitreous form is obtained, which is insulating. By annealing it is transformed into metallic selenium which is conducting. Selenium combines with most metals, and it thus usually contains selenides when fused in contact with them. That this is the case has been proved by M. Coste, who fused selenium on gold leaf and then drove it off by heat, when it left a residue of pure gold. The resistance usually attributed to selenium is untrustworthy for that reason. Carbon electrodes are not open to this objection, and the author has, therefore, operated with these. When the vitreous selenium is transformed into the metallic variety, it shows under the microscope a number of fissures and pointed geodes. The number of fissures varies greatly with the mode of transformation and the rate of cooling. Hence the different results obtained by various observers. In spite of the fissures, the metallic variety is denser than the vitreous. The contraction commences on the surface, and leaves the fissures as it proceeds inward. When light impinges on the selenium, some fissures are bridged, and the resistance thus decreases. The author found a resistance of 86,000 ohms in a stick 9 centimeters long and of ½ square millimeter sectional area.—M. Coste, Comptes Rendus, November 6, 1905.

ELECTRO-OPTIC PROPERTIES OF CARBON.—The electromagnetic theory of light suggests that certain specimens of carbon, possessing a high electric conductivity, might possess a high reflective power for rays of great wave-length, provided the passage of electricity through them takes place in the same manner as in metals. E. Aschkinass has found, indeed, that certain carbons possess a reflective power of 100 per cent for waves of the Hertzian order. But the influence of the good conductivity is already sufficiently apparent in the infra-red spectrum. In gas carbon, Siemens arc-lamp carbon and graphite, the curve of reflecting power rises immediately on leaving the visible spectrum, and continues to do so until the Hertzian waves are reached. Thus for polished gas-carbon the reflective power is 4.4 at 0.589μ, and 56.5 at 51.2μ. Anthracite also exhibits considerable reflective power in the infra-red, but this never goes beyond 14, even for Hertzian waves. This anomaly is to be expected in consideration of its comparatively low conductivity. It, therefore, also transmits some of the waves, and its refractive index for infinitely long waves, as calculated from the reflection, comes out as 2.2. The refractive index of diamond for yellow light is 2.4.—E. Aschkinass, Physikalische Zeitschrift, November 9, 1905.

CONDUCTIVITY OF DILUTE SULPHURIC ACID.—As is well known, the equivalent conductivity of neutral salts when dissolved in water approaches a limiting value as the dilution is increased, and, in terms of the ionization theory, this limiting value corresponds with complete ionization. With solutions of acids and alkalies, however, the phenomena are different. As dilution proceeds, the equivalent conductivity reaches a maximum at a concentration of about a one-thousandth or a two-thousandth of a gramme-equivalent per liter, and then falls rapidly as the dilution is pushed farther. It has been supposed that this diminution of equivalent conductivity at extreme dilutions is due to interaction between the solute and the impurities which remain even in redistilled water. W. C. D. Whetham has endeavored to elucidate this question by adding slight impurities to pure water, and finds that within the limits of experimental error, the equivalent conductivity of a dilute acid is not affected by boiling the water under diminished pressure, though the conductivity of the solvent is thereby much diminished. The equivalent conductivity of the acid is also unaffected by the addition of a small quantity of potassium chloride to the water, though the conductivity of the solvent is thereby much increased. But, by the addition of a little carbonic acid, the equivalent conductivity of the sulphuric acid is diminished appreciably. It is natural to conclude that, while the presence of carbonic acid would produce a diminution of equivalent conductivity of the same character as that observed, it does not explain the total effect. It is just possible that the residue may be due to slight traces of ammonia, whose effect the author has not yet studied.—W. C. D. Whetham, paper read before the Royal Society, November 16, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

SCIENCE NOTES.

Science is knowledge organized, and the scientific spirit is merely the correct manner of acquiring and using knowledge. The process is threefold; observation, generalization, and inference. Observation must be done at first hand. No amount of reading about objects will suffice. After observation comes the stage of generalization—a mental process in which the healthy mind revels; lastly, inference as to truths not yet observed. This is the complete cycle which only the greatest minds can compass, but all of us can catch the spirit of dealing with facts at first hand and drawing inferences from them. This sounds like a very simple principle; yet, simple though it may be, it is profoundly influencing our entire civilization for the better.

Loew observed that marked injury results when such a plant as *Spirogyra* is placed in a solution of a magnesium salt, or in a solution in which magnesium is in excess. From all of the results obtained Loew has inferred that there is present in all plants requiring calcium an essential calcium protein compound. When magnesium must, owing to the predominance of this element, be substituted for calcium in this proteid compound there results a lessening of the capacity for imbibition, attended by unfavorable consequences. It has been further ascertained by the work of May, Kearney and Cameron, Kusano, Aso and others, that there is for each plant a certain more or less definite relation between calcium and magnesium. Nevertheless, further experimental proof is needed before this brilliant hypothesis may be acceptable in its entirety. Magnesium compounds exert upon the marine algæ the least injurious action of all nutrient bases. On the other hand, it has not been demonstrated that the marine algæ require calcium.

Although inanimate matter moves under the action of forces which are incomparably simpler than those governing living beings, yet the problems of the physicist and the astronomer are scarcely less complex than those which present themselves to the biologist. The mystery of life remains as impenetrable as ever, and in his evolutionary speculations the biologist does not attempt to explain life itself, but, adopting as his unit the animal as a whole, discusses its relationships to other animals and to the surrounding conditions. The physicist, on the other hand, is irresistibly impelled to form theories as to the intimate constitution of the ultimate parts of matter, and he desires further to piece together the past histories and the future fates of planets, stars, and nebulæ. If then the speculations of the physicist seem in some respects less advanced than those of the biologist, it is chiefly because he is more ambitious in his aims. Physicists and astronomers have not yet found their Johannesburg or Kimberley.

It is but fair to admit that to-day Germany surpasses all other nations in the extent of her system of technical education, yet we, in the United States, can justly claim that we excel her in three points; the superiority of our laboratory training, especially in mechanical and electrical engineering, the effective combination of scientific theory with practical knowledge, and the emphasis which we place upon originality and inventiveness. In the United States we have not made the mistake which England has made in placing scientific education on a narrow basis, nor have we gone to the theoretical extreme of Germany. We have been wise in making a judicious combination of theory and practice, and have placed our superstructure of scientific education upon the solid basis of a good liberal education, so that our scientific man is not merely a specialist, but a man of broad human sympathies. No man who is engaged in giving technical education can fail to recognize that among young Americans there is a strong and persistent demand for just this kind of an education. It appeals especially to those young men who have a predisposition to science and its applications, who are constantly on the search for methods of improvement not to be found in the pages of Plato or Aristotle. Their call is for an education which will enable them to give expression to their ideas in concrete form; when they study mathematics, they want it as a tool, as something they can use in the expression of their scientific ideas; if they study French or German, they want the scientific vocabulary; if they study English, it is for the purpose of being able to express their ideas more clearly; if they study history, it is the industrial and economic side which interests them most; if they study logic and psychology, it is for the purpose of making their ideas clearer and more exact; if they are studying any of the manifold forms of mechanical, electrical, or civil engineering, it is for the purpose of applying them in their professional work.

TRADE NOTES AND FORMULÆ.

To Fasten Marble Slabs.—The marble tops of tables, commodes, etc., which may have become loose, can be firmly refastened by a cement made of joiner's glue and gypsum, which is very strong and durable. The glue is first soaked for some hours in cold water, and then brought to boiling over a stove. When entirely dissolved, a thin paste of gypsum is made with water, poured in, and the mixture stirred vigorously. Apply quickly to the marble and press it into place. The gypsum hardens very quickly, hence the need of performing the operation as rapidly as possible. The slab should be placed under a weight and left to dry two days.—Die Werkstatt.

Oxidized Steel.—A black oxidized finish on steel is obtained by the following method: A coating of ferric oxide is produced upon the surface of the steel, and this is converted into the black oxide by the action of hot water, 900-1,000 deg. C., the process being repeated until the stratum has the desired depth. The metal is then immersed in luke-warm water, to remove any acid or saline components, and lastly olive oil is poured over it.

A preparation consisting of 375 parts by weight of fluid ferric chloride, 25 parts of blue vitriol, 100 parts of nitric acid, 150 parts of alcohol, and 5,000 parts of water, is also used for this purpose. Or 50 parts of mercuric sublimate, 50 parts of ammonium chloride, and 1,000 parts of water may be employed.—Neueste Erfindungen.

Soap Varnish.—This kind of varnish is especially valuable for some purposes by reason of its great elasticity and because of the fact that it is not at all affected by water. It can be manufactured very cheaply, the simplest method being as follows: Good tallow grain soap is boiled with soft water until a clear solution is obtained, which is filtered, while hot, through several thick cloths. It is then reheated and diluted with an equal amount of soft water, and enough of a boiling hot solution of alum is added to cause a precipitate of aluminium sebate. This precipitate is washed with boiling water and dried, then heated in a vessel placed in a water bath until it has become transparent. Meanwhile turpentine oil has been heated nearly to the boiling point in another kettle, and enough of the alumina soap is added to this to make a solution of the consistency of thick varnish.—Seifensieder Zeitung, Vienna.

Different Metals Joined by Aluminium.—By a new method, patented in Germany, two different metals can be joined together by means of sheet copper covered with aluminium. Heavy sheets of copper are rubbed on both sides with aluminium, in the customary way, then covered with sheets of aluminium of corresponding weight, heated, and rolled to the desired thickness. The sheet copper thus prepared, covered on both sides with thin layers of aluminium, is now softened by heating, cleansed on both sides, and placed between the two metals to be joined, brass and steel, for example. The surface of these is first cleaned, and after the copper-aluminium has been placed between them, they are heated in a muffle furnace to the welding temperature of aluminium. In this state they are joined by rolling or pressing, so that during subsequent heating to a temperature near to that at which brass melts, there can be no oxidation of the two surfaces. At this temperature the whole mass is rolled, whereby the real welding takes place.—Neueste Erfindungen und Erfahrungen.

Determination of Chromium in Chromated Irons.—To 0.2 to 0.3 gramme of finely-pulverized ore are added 2 to 3 grammes of a mixture of 1 part sodium hydrate and 2 parts calcined magnesia oxide; the mixture is heated for an hour in a platinum crucible imperfectly closed, taking care to stir from time to time with a platinum spatula, in order to bring all parts in contact with the oxygen of the air. Although crucibles of platinum are slightly attacked, they are, with reference to convenience, to be preferred to gold or silver. After cooling, the contents of the crucible are emptied into a beaker and dissolved in dilute sulphuric acid in excess. The solution without previous filtration is diluted with 1,500 cubic centimeters of water and titrated, according to the Schwarz method, which ferrous sulphate and permanganate. After the addition of the iron solution the liquid becomes green, and the excess of permanganate is ascertained by transparency and the violet coloration assumed by the liquid. With a little experience it can be ascertained with exactitude.—Chemik.

Hints for the Manufacture of Lemonade.—A frequent trouble in the manufacture of lemonade is that it becomes ropy; and efforts have been made to discover the cause of this very unpleasant condition, which is liable to be of injury to the manufacturer. It was supposed at first that it resulted from lack of cleanliness in handling the bottles, and every means was taken to have them perfectly clean and to destroy all germs. After the use of agents for the latter purpose, the bottles were carefully rinsed in water. But the disagreeable phenomenon still continued to appear. Fleischmann, of Zurich, writing in the Schweizerische Wochenschrift für Chemie und Pharmacie, claims to have found the cause in the sugar used for the syrup. He says that this must be of the very best quality, and not blued. The best is that in small crystals, containing no ultramarine; or if it is desired to save the trouble of boiling the syrup, the so-called liquid fruit sugar will do.

This is worthy of notice by all manufacturers of lemonade or other products prepared with sugar syrup, who may take it as a warning to avoid blued sugar.

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